PB84-910208

U.S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SELECTED WATER RESOURCES ABSTRACTS

VOLUME 17, NUMBER 8
AUGUST 1984

W84-02480 -- W84-02950
CODEN: SWRABW

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SELECTED WATER RESOURCES ABSTRACTS

A monthly publication of the Geological Survey
U.S. Department of the Interior

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The Secretary of the Interior has determined that the publication of the periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Office of Management ond Budget through September 30, 1985.

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PREFACE

Selected Water Resources Abstracts, a monthly journal, includes abstracts of current and earlier pertinent monographs, journal articles, reports, and other publication formats. These documents cover water resources as treated in the life, physical, and social sciences and the related engineering and legal aspects of the characteristics, supply condition, conservation, control, use, or management of water resources. Each abstract includes a full bibliographic citation and a set of descriptors which are listed in the **Water Resources Thesaurus.** The abstract entries are classified into 10 fields and 60 groups similar to the water resources research categories established by the Committee on Water Resources Research of the then Federal Council for Science and Technology.

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Comments and suggestions concerning the contents and arrangement of this bulletin are welcome.

Water Resources Scientific
Information Center
U.S. Geological Survey, MS 421
Reston, VA 22092

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SELECTED WATER RESOURCES ABSTRACTS

1. NATURE OF WATER

1B. Aqueous Solutions and Suspensions

WATER TRANSFER COEFFICIENT IN ADSORPTIVE POROUS BODY,
Kyoto Univ. (Japan). Dept. of Chemical Engineering.
R. Toei, H. Imakoma, H. Tamon, and M. Okazaki.
Journal of Chemical Engineering, Vol. 16, No. 5, p 364-369, October, 1983. 7 Fig, 1 Tab, 9 Ref. Japanese Ministry of Education, Science and Culture grant 555377.

Descriptors: *Water transport, *Porosity, Porous media, Adsorption, Capillary water, Water vapor.

Water transport in wet porous materials is expressed as the simultaneous transport of adsorbed water, capillary water and water vapor. The sum of the surface flow coefficient and the liquid water transfer coefficient is defined as the water transfer coefficient in this report. The water transfer coefficient was measured by a modified method which is a kind of constant volume method for adsorption equilibrium. An activated alumina whose pores are fine was used as the experimental material. This method appears to be a simple experimental one to measure the water transfer coefficient, which represents the sum of transport of surface flow and liquid water in a short period using an easy but strict analysis. This coefficient in the range over a few orders of magnitude was measured by changing only the sample length. The results of experiments at temperatures of 30 to 50 degrees C could be well interpreted by the model described. (Baker-IVI)
W84-02797

2. WATER CYCLE

2A. General

IMPROVED PARAMETER INFERENCE IN CATCHMENT MODELS; 1. EVALUATING PARAMETER UNCERTAINTY,
G. Kuczera.
Water Resources Research, Vol. 19, No. 5, p 1151-1162, October, 1983. 12 Fig, 4 Tab, 33 Ref.

Descriptors: *Hydrologic models, *Catchment areas, *Statistical models, Runoff, Soil water, Model studies, Stochastic process.

A Bayesian methodology is developed to evaluate parameter uncertainty in catchment models fitted to a hydrologic response such as runoff, the goal being to improve the chance of successful regionalization. The catchment model is posed as a nonlinear regression model with stochastic errors possibly being both autocorrelated and heteroscedastic. The end result of this methodology, which may use Box-Cox power transformations and ARMA error models, is the posterior distribution, which summarizes what is known about the catchment model parameters. This can be simplified to a multivariate normal provided a linearization in parameter space is acceptable; means of checking and improving this assumption are discussed. The posterior standard deviations give a direct measure of parameter uncertainty, and study of the posterior correlation matrix can indicate what kinds of data are required to improve the precision of poorly determined parameters. Finally, a case study involving a nine-parameter catchment model fitted to monthly runoff and soil moisture data is presented. It is shown that use of ordinary least squares when its underlying error assumptions are violated gives an erroneous description of parameter uncertainty. (Author's abstract)
W84-02760

IMPROVED PARAMETER INFERENCE IN CATCHMENT MODELS; 2. COMBINING DIFFERENT KINDS OF HYDROLOGIC DATA AND TESTING THEIR COMPATIBILITY,
G. Kuczera.
Water Resources Research, Vol. 19, No. 5, p 1163-1172, October, 1983. 11 Fig, 7 Tab, 12 Ref, 2 Append.

Descriptors: *Hydrologic models, *Catchment areas, *Runoff, Mathemetical models, Statistical methods, Rainfall-runoff relationships, Bayesian methodology.

Some of the parameters of catchment models fitted to runoff data are often poorly determined, thereby making the task of developing useful regionalization relationships more difficult. The approach taken here is based on the notion that the information in a rainfall-runoff record can be supplemented by observations of other hydrologic responses such as soil moisture and field studies of hydrologic responses such as interception. The Bayesian methodology is extended to utilize several kinds of hydrologic data in parameter inference, the goal being to improve the precision of poorly determined parameters. The concept of compatibility is developed using statistical hypothesis tests. Different kinds of data are said to be compatible if differences between their fitted parameters are not statistically significant. A hierachy of three levels of information is introduced to enable systematic checking for compatibility. The compatibility tests, posed as statistical hypothesis tests, check whether differences between parameters inferred from different kinds of data are statistically significant. Application of this methodology to a case study indicates that the precision of poorly determined parameters fitted to runoff data can be substantially improved when runoff data are pooled with other kinds of hydrologic data. Before pooling different kinds of data (including split samples) it is essential to check their compatibility. When incompatible data are pooled, the ability of the catchment model to predict runoff can be undermined and also biases can be induced in the inferred parameters. (Moore-IVI)
W84-02761

SOME ALGORITHMS FOR PARAMETER ESTIMATION IN WATER RESOURCES SYSTEMS,
Louisiana State Univ., Baton Rouge. Dept. of Mechanical Engineering.
H. Sehitoglu.
Water Resources Research, Vol. 19, No. 5, p 1193-1202, October, 1983. 9 Fig, 23 Ref.

Descriptors: *Mathematical models, *Parameter identification, Model studies, Simulation, Finite-element models.

Many of the existing parameter identification schemes employ off-line algorithms, and so cannot be used in real-time applications. The problem of on-line parameter identification in some water resources systems was successfully resolved by developing proportional and proportional plus integral type algorithms. Lyapunov's stability theorem was applied to obtain recursive adjustment equations. This approach guarantees the convergence of the identification process. The proposed algorithms can identify unknown parameters of linear and nonlinear models. The application of the method depends on the selection of several algorithmic variables, such as gain constants, filter cutoff frequency, finite-element size, etc. Simulation studies indicated that the method is convergent for a wide range of gain values. The filter frequency usually affects the identification response time. Low values of the frequency result in sluggish output, whereas high values may produce undesirable large oscillations. In general, decreasing the finite-element size improves the final accuracy. To further enhance the accuracy, higher-order finite-element basis functions may be used in obtaining the finite-element models. (Moore-IVI)
W84-02763

AGGREGATION AND ESTIMATION FOR LOW-ORDER PERIODIC ARMA MODELS,
Colorado State Univ., Fort Collins. Dept. of Recreation Resources.
A. V. Vecchia, J. T. Obeysekera, J. D. Salas, and D. C. Boes.
Water Resources Research, Vol. 19, No. 5, p 1297-1306, October, 1983. 10 Fig, 6 Tab, 8 Ref. NSF grant CEE-8110782.

Descriptors: *Hydraulic models, *Seasonal variation, Estimating, Aggregates, Statistical studies, Time series analysis.

An aggregation approach is presented in which the seasonal time series is modeled and then aggregated, producing a specified compatible model for the aggregated series. The assumed periodic (seasonal) model is defined and the resulting aggregated model is derived. Parameter estimation is considered and some results on the goodness, as quantified by bias and variance, of the proposed estimators are given. A significant gain in the precision of the estimators at the aggregated level is noted when the seasonal data and its model are used as opposed to the aggregated (annual) data and its model. (Baker-IVI)
W84-02769

RELIABILITY OF CALIBRATION OF A MONTHLY RAINFALL-RUNOFF MODEL: THE SEMIARID CASE,
Rhodes Univ., Grahamstown (South Africa).
A. H. M. Gorgens.
Hydrological Sciences Journal, Vol. 28, No. 4, p 485-498, December, 1983. 6 Fig, 4 Tab, 12 Ref.

Descriptors: *Rainfall-runoff relationships, *Semiarid lands, *Mathematical models, Streamflow, Ecca basin, South Africa, Precipitation, Surface water, Calibration.

A monthly conceptual rainfall-runoff model that enjoys fairly widespread use in South Africa was calibrated for each of 50 calibration samples of lengths 3-20 years, drawn from a synthetic 101-year semiarid streamflow time series generated with the Stanford Watershed Model. The ability of Pitman's model to reconstruct the original 101 years of monthly streamflow for each of the 50 calibrations was then examined against a set of statistics of monthly and annual streamflows. The variabilities of key model parameters associated with different lengths of calibration period were also investigated. It is well worthwhile to increase the calibration period to about 15 years in order to reduce errors in reconstructed flow statistics. Merely increasing the length of calibration period from 6 to 10 years may decrease the error in most regenerated flow statistics by 30-50%. A fair amount of variability in 'optimum' parameters, however, seems unavoidable, even at longer calibration periods, though this may also partly be due to imperfect model calibration. The effects of this variability are greatly attenuated in the reconstructed flow statistics due to parameter interdependence. (Author's abstract)
W84-02827

REFLECTIONS ON RIVERS, RESEARCH, AND ROUSE,
Iowa Univ., Iowa City. Inst. of Hydraulic Research.
J. F. Kennedy.
Journal of Hydraulic Engineering, Vol. 109, No. 10, p 1254-1271, October, 1983. 5 Fig, 28 Ref.

Descriptors: *River flow, *Hydraulic models, Hydraulic roughness, Sediment discharge, Hydraulic engineering, Mathematical models, Friction, Channel flow, Water temperature, Computer models.

The ways in which rivers adjust their hydraulic roughness to accommodate only loosely correlated changes in their water and sediment discharges are discussed. An assessment of the current status of river engineering leads to the conclusion that the major deficiencies of mathematical models of river flow have been their failure to represent the dependence of friction factor on sediment discharge or concentration, and to include temperature and channel-curvature effects. It is argued that the data

and computational resources now are at hand to permit development of more inclusive analyses of alluvial-channel flow. A recently developed computer-based predictor for river-flow sediment discharge and friction factor, and an analytical model of flow in river ends are outlined. Reflections on Rouse's research and writing conclude the paper. (Author's abstract)
W84-02863

THE USE OF AUTOCORRELATION AND SPECTRAL ANALYSES TO OBTAIN A BETTER UNDERSTANDING OF HYDROLOGICAL SYSTEMS (POUR UNE MEILLEURE CONNAISSANCE DES SYSTEMES HYDROLOGIQUES A PARTIR DES ANALYSES CORELATOIRE ET SPECTRALE),
Centre National de la Recherche Scientifique, Moulis (France). Lab. Souterrain.
A. Mangin.
Journal of Hydrology, Vol. 67, No. 1-4, p 25-43, 1984. 8 Fig, 1 Tab, 37 Ref.

Descriptors: *Karst hydrology, *Hydrologic systems, *Autocorrelation, *Spectral analysis, Pyrenees, France, Spain, Rainfall, Hydrologic cycle, Discharge hydrographs.

Using the correlogram and variance spectral density, the time series of rainfall and discharge of a hydrological system are analysed in a descriptive way differing from the traditional method. From a methodological viewpoint some computational working choices are made. Applied to three karstic systems in the Pyrenean Mountains (France-Spain), these analyses permitted a comparison and a study of the different reactions of these three systems. They showed the presence of memory effects which modulated the input rainfall for short, medium and long term. These modulations characterize each system. They reflect the storages and the manner in which these fill and empty, thus indicating the karstification of the aquifer. The examples discussed indicate that these analyses provide an excellent method for the investigation of a hydrological system. (Author's abstract)
W84-02884

OVERLAND FLOW ON CONVERGING AND DIVERGING SURFACES - KINEMATIC MODEL AND SIMILARITY SOLUTIONS,
Griffith Univ., Nathan (Australia). School of Australian Environmental Studies.
S. Y. Campbell, J.-Y. Parlange, and C. W. Rose.
Journal of Hydrology, Vol. 67, No. 1-4, p 367-374, 1983. 2 Fig, 1 Tab, 10 Ref.

Descriptors: *Model studies, *Surface runoff, *Overland flow, Kinematics, Cones, Steady state flow, Mathematical equations, Rainfall, Rainfall-runoff relationships.

An understanding of the process of surface runoff is vital in areas such as watershed hydrology and soil erosion. Through the re-examination of kinematic flow on a converging surface, a new method of solution has been found in the form of a similarity solution, reducing the problem to a first order ordinary differential equation which can be integrated easily by standard Runge-Kutta integration. When this method is applied to the geometry of a cone, an exact analytical solution is found which represents the steady state flow regime. This provides a check for numerical solution procedures used, which are found to be very accurate. (Baker-IVI)
W84-02903

2B. Precipitation

LONG-TERM VARIATIONS IN THE SOUTHERN OSCILLATION, EL NINO, AND CHILEAN SUBTROPICAL RAINFALL,
Oregon State Univ., Corvallis. School of Oceanography.
W. H. Quinn, and V. T. Neal.
Fishery Bulletin, Vol. 81, No. 2, p 363-374, April, 1983. 3 Fig, 6 Tab, 39 Ref. NSF grant ATM-7820419, NOAA contract NA-80-RAC-00003.

Descriptors: *Rainfall, *Climatology, Climate, Chile, South America, Southern Oscillation, El Nino, Variability, Subtropic zone, Climatic zones, Fisheries.

In order to better understand the causes and variations of Southern Oscillation-related activity, a 120 year record of the activity along the west coast of South America was studied. Significant decreases in the frequency of occurrence of moderate/strong El Ninos and the related abnormally heavy amounts of Chilean subtropical rainfall were noted over the past half century. A significant change took place between 1927 and 1931. A significant decrease in average annual rainfall was noted over subtropical Chile after 1944. Below normal pressures in the southeast Pacific subtropical high over the past 6 years coincide timewise with generally above normal sea surface temperatures over this region. An associated weakening of the southeast trade system is hypothesized to be responsible for environmental changes that contribute to the large alteration in composition of the pelagic biomass in both the Peruvian and northern Chilean fishery regions over recent years. (Baker-IVI)
W84-02645

CHARACTERISTICS OF THE BERGSCHRUND OF AN AVALANCHE-CONE GLACIER IN THE CANADIAN ROCKY MOUNTAINS,
Calgary Univ. (Alberta). Dept. of Geology and Geophysis.
G. Osborn.
Journal of Glaciology, Vol. 29, No. 101, p 55-69, 1983. 16 Fig, 7 Ref. Canadian N.S.E.R.C. grant A9026.

Descriptors: *Glaciers, *Bergschrund, Snow, Ice, Crevasses, Mount Chephren, Alberta.

Field study of the bergschrund of a small avalanche-cone glacier at the base of Mt. Chephren, in Banff National Park, has been carried out as part of a general exploratory study of glacier-head crevasses in the Canadian Rockies. The bergschrund consists of a wide, shallow, partly bedrock-floored gap, underneath which extends a nearly vertical Randkluft, and a small, offset, subsidiary crevasse (or crevasses). The following observations regarding the behavior of the bergschrund and ice adjacent to it are of particular interest: (1) topography of the subglacial bedrock is a control on the location of the main bergschrund and subsidiary crevasses, (2) the main bergschrund and subsidiary crevasse(s) are connected by subglacial gaps between bedrock and ice; the gaps are part of the 'bergschrund system', (3) snow/ice immediately down-glacier of the bergschrund system moves nearly vertical downward in response to rotational flow of the glacier, allowing the bergschrund components to keep the same location and size from year to year, (4) an independent accumulation, flow, and ablation system exists in the snow/ice up-glacier of the bergschrund system, (5) most of the void space in the bergschrund system is maintained through the winter, although the wide, shallow part of the main bergschrund fills up with snow, (6) some mass transfer of snow/ice occurs across the bergschrund system, (7) displacement across the bergschrund due to flow of the main glacier body results in significantly more snow being deposited each winter down-glacier of the bergschrund than up-glacier of it. (Author's abstract)
W84-02686

RAINFALL INTENSITY-DURATION-FREQUENCY FORMULAS,
Geological Survey, NSTL Station, MS. Gulf Coast Hydroscience Center.
C.-L. Chen.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1603-1621, December, 1983. 3 Fig, 7 Tab, 16 Ref.

Descriptors: *Rainfall intensity, *Rainfall duration, *Rainfall frequency, Return period, Spatial distribution, Mathematical models.

A new general rainfall intensity-duration-frequency formula is presented, utilizing a method similar to, but more accurate than one previously developed. The depth-duration ratio, though likely to be independent of return period, varies approximately from 10%-60% with the geographical location. The depth-frequency ratio, though likely to be independent of duration, varies approximately in the range of 1.33-1.63 with geographical location. The previously developed formula was based on the average depth-duration ratio of about 40% and the mean depth-frequency ratio of 1.48. This formula requires only the 10-yr 1-hr rainfall depth instead of the three rainfall depths (i.e., 10-yr 1-hr, 10-yr 24-hr, and 100-yr 1-hr). This value alone cannot measure the geographic variations of rainfall. The ratios of 1-hr to corresponding 24-hr depth and 100-yr to corresponding 10-yr depth can be computed from the required three rainfall depths in the present method so that geographical variation of rainfall can be evaluated in terms of both ratios. The general formula outperforms the previously developed formula in accuracy, regardless of whether values are within or outside the range of applicability of the previously developed formula. (Moore-IVI)
W84-02875

ASPECTS OF RAINFALL EXCESS FROM SPATIALLY VARYING HYDROLOGICAL PARAMETERS,
Commonwealth Scientific and Industrial Research Organization, Wembley (Australia). Div. of Mathematics and Statistics.
R. A. Maller, and M. L. Sharma.
Journal of Hydrology, Vol. 67, No. 1-4, p 115-127, 1984. 3 Fig, 16 Ref.

Descriptors: *Excessive precipitation, *Spacial distribution, *Parametric hydrology, Rainfall, Ponding, Mathematical studies, Phillip's two-parameter equation, Infiltration.

The present rainfall excess measurement methods is subject to limitations of computer space and high costs. Rainfall excess for a given rain intensity can be calculated though from the extended form of Philip's two-parameter equation. This equation is assumed to hold after a time when the water has started to pond on the soil surface. A direct mathematical procedure is developed by which the distribution of areal cumulative infiltration can be calculated from the distributions of S and Ks. This enables detailed analysis of effects of joint variability of S and Ks on the expectation and standard deviation of areal rainfall excess. The effect of variability in the estimation of the mean parameter in the log-normal distribution of S on the distribution of tp can assess the distribution of tp to within a given accuracy for the number of samples required. The expected value of tp cannot be investigated in this way, since it may be infinite, even in the set of sample points where ponding does eventually occur. (Murphy-IVI)
W84-02889

2C. Snow, Ice, and Frost

THE IMPORTANCE OF PRESSURIZED SUBGLACIAL WATER IN SEPARATION AND SLIDING AT THE GLACIER BED,
National Aeronautics and Space Administration, Greenbelt, MD. Goddard Space Flight Center.
R. Bindschadler.
Journal of Glaciology, Vol. 29, No. 101, p 3-19, 1983. 5 Fig, 1 Tab, 32 Ref.

Descriptors: *Glaciers, *Glacier surges, *Sliding, Subglacial water, Water pressure, Bed separation index, Basal shear stress, Variegated Glacier, Ice Stream B, Antarctica, Columbia Glacier, Alaska.

Many glaciers slide over their beds. Surging glaciers are examples of situations in which sliding dominates the ice motion, but many normal glaciers also exhibit appreciable sliding motion. The effect of pressurized subglacial water on the sliding process is examined by a parameter called the 'bed separation index'. This index indicates the relative extent of cavity formation by combining the effects of variation of bed-normal stress across undulations and steady-state water pressure in a Rothlisberger

conduit at the glacier bed. Data from three glaciers of widely varying size are used to test the correlation of the bed separation index with inferred sliding rates. For Columbia Glacier (Alaska) and Ice Stream B in West Antarctica, high water pressure enhances sliding. More complete data from the third test case, Variegated Glacier, are used to compare a number of possible formulations of a 'sliding law'. Over time scale less than years, the spatial and temporal variations of water pressure play the active role, and basal sheer stress the passive role in basal sliding. It then becomes obvious that water pressure is one of the most fundamental parameters of the sliding process. Consideration of the transverse variation of water pressure and bed separation index indicates that, in the main conduit, only a rise of water presure above a critical level should cause a substantial increase in the separation across the glacier. The duration of the increased sliding would last only as long as it took for the glacier hydraulics to adjust. This is consistent with the observations made on Variegated Glacier where both the basal stress and the average summer sliding velocity increased annually through the latter half of the quiescent phase, before the surge occurred. (Moore-IVI)
W84-02684

BASAL WATER FILM, BASAL WATER PRESSURE, AND VELOCITY OF TRAVELING WAVES ON GLACIERS,
Northwestern Univ., Evanston, IL. Dept. of Materials Science.
J. Weertman, and G. E. Birchfield.
Journal of Glaciology, Vol. 29, No. 101, p 20-27, 1983. 2 Fig, 6 Ref. NSF grants ATM-78/3961 and ATM-81/1138.

Descriptors: *Glaciers, *Glacier surges, *Water pressure, *Traveling waves, Basal water pressure, Sliding.

Because of seasonal melt-water fluctuations, temperate glaciers usually have large seasonal fluctuations in their motion although the basal shear stress remains almost unchanged during a period of one year. The theory of traveling waves on glaciers is extended to cover the situation where the presence of abundant basal water or increased basal water pressure produces increased sliding of a glacier over its bed. The ratio of traveling-wave velocity to surface velocity is independent of the amount of water or the basal water pressure. The theoretical value of this ratio, about 4 to 5, agrees with that found in field measurements (the most recent data are from Mer de Glace). Field observations of traveling-wave velocities lend strong support to any glacier sliding theory in which the sliding velocity is proportional to the basal shear stress raised to about a second to fifth power and in which the sliding velocity is a function of either or both the amount of water at the bed of a glacier and the pressure within this water. The traveling-wave observations are almost inexplicable to any theory in which the sliding velocity does not have this dependence on basal shear stress. (Moore-IVI)
W84-02685

MODIFICATIONS TO THE THEORY OF INTRAGLACIAL WATERWAYS FOR THE CASE OF SUBGLACIAL ONES,
Laboratoire de Glaciologie et Geophysique de l'Environnement, Grenoble (France).
L. Lliboutry.
Journal of Glaciology, Vol. 29, No. 102, p 216-226, 1983. 1 Fig, 18 Ref.

Descriptors: *Glaciers, *Subglacial waterways, *Glaciohydrology, Plastic deformation, Ice, Groundwater, Heat, Sliding.

It is argued that in temperature mountain glaciers, waterways are subglacial. It is shown that the theory of Spring and Hutter (1981, Cold Regions Science and Technology 4(3):227-244) for intraglacial flooded conduits leads to an equation for the grade line which differs from Rothlisberger's (1972, J. of Glaciology 11(62):177-203) only by negligible terms, and a slight modification of the exponent of the discharge. For a subglacial flooded waterway two important processes should instead be introduced: the enhancement of plastic deformation on the up-stream side of bumps, and the heat afforded by ground water (which in winter accounts for most of the discharge). The theory modified in this way explains why Rothlisberger had to adopt an unrealistic value for the rheological parameter of ice. It leads to the conclusion that in areas which are not overdeepened, most of the year subglacial waterways should remain not flooded and at atmospheric pressure. The case of overdeepening is examined. Finally the implications of this new model for glacier sliding theory are demonstrated. (Author's abstract)
W84-02687

WATERWAYS, ICE PERMEABILITY AT DEPTH, AND WATER PRESSURES AT GLACIER D'ARGENTIERE, FRENCH ALPS,
Laboratoire de Glaciologie et Geophysique de l'Environnement, Grenoble (France).
D. Hantz, and L. Lliboutry.
Journal of Glaciology, Vol. 29, No. 102, p 227-239, 1983. 8 Fig, 20 Ref.

Descriptors: *Glacier d'Argentiere, *France, *Ice permeability, *Glaciohydrology, *Water pressure, Pore pressure, Air temperature, Meltwater, Glacial streams.

To clear up the changes which had happened at the subglacial catchment of glacier d'Argentiere, an extensive study, with 31 borings and a coring down to the bottom (240 m) was performed in 1979/80, just upstream from the catchment, in an overdeepened area. The behavior of the water level during boring with a hot water jet, and just after, was different from one bore hole to another, mainly because transient leaks appeared in the walls of bore holes. Next, the water level fluctuated slowly, in the same way in most of the deep bore holes, showing that glacier ice below about 100 m deep is slightly pervious. What is so measured is the pore pressure of water in deep ice. The piezometric gradient between bore holes, and the time lag between fluctuations of water level, which increases with distance from the right bank, shows that there is no waterway at the bottom of the overdeepened area, save at its up-stream end. Most of the melt water must flow between ice and rock along the right bank, its free surface rising by about 150 m during the increased discharge in June. No clear-cut correlation between the bottom pore pressure and the air temperature or the discharge at the subglacial catchment down-stream was found. (Author's abstract)
W84-02688

SPECTRAL REFLECTANCES OF SNOW AND FRESH-WATER ICE FROM 340 THROUGH 1,100 NM,
National Oceanic and Atmospheric Administration, Ann Arbor, MI. Great Lakes Environmental Research Lab.
S. J. Bolsenga.
Journal of Glaciology, Vol. 29, No. 102, p 296-305, 1983. 5 Fig, 25 Ref.

Descriptors: *Spectral reflectance, *Remote sensing, *Snow, *Ice, Slush, Brash, Ice cover, Reflectance.

Measured spectral reflectances of new and moderately metamorphosed snow were generally >80% from 340-950 nm. From 950-1,100 nm a characteristic dip and rise of spectral reflectances occurred. One spectroradiometer scan over a deteriorated snow patch showed much lower spectral reflectances than fresh snow, but the shape of the curve remained similar to that of fresher snow. Spectral reflectances for clear ice contrasted sharply with those for snow. In general, values were <10% and the curves lacked distinctive shape. Higher spectral reflectances, due to 'lighter'-appearing ice in the measurement area, were measured at some sites. Refrozen slush, pancake, brash, and slush curd ice revealed spectral reflectance curves similar in form to each other, but which varied significantly in the range of spectral reflectances for each ice type. Generally, reflectances rose slowly from 340 nm to a peak near 550 nm. From 550-775 nm reflectances decreased slowly but significantly. A slight dip and rise in reflectances occurred from 775-850 nm after which values again dipped significantly (850-900 nm). From 950-1,100 nm, a dip and rise in reflectances similar to that for snow was observed. The amount of slush included seems to control the reflectances of these ice types. All measurements were acquired with a pair of scanning spectroradiometers having picowatt accuracy, adapted to obtain, automatically, simultaneous readings of incident and reflected radiation from 340-1,100 nm. The spectroradiometers were field-calibrated using Sun-plus-sky radiation as a calibration source. (Author's abstract)
W84-02689

AREAL VALUE OF DEGREE-DAY FACTOR,
Kwara State Coll. of Technology, Ilorin (Nigeria). Dept. of Survey.
A. K. Bagchi.
Hydrological Sciences Journal, Vol. 28, No. 4, December, 1983. 8 Fig, 3 Tab, 6 Ref.

Descriptors: *Snowmelt, *Degree-days, *Runoff, Himalayas, Beas Basin, Streamflow, Snow cover, Model studies, Mathematical models.

A method of determination of areal value of degree-day factor by plotting basic snowmelt, against the degree-day multiplied by the area of the snow cover is presented. Beas basin above Manali situated in the western Himalayas was chosen as the experimental basin. The question of open patches in the snow cover poses difficult problems in conceptual modelling of snowmelt runoff. Some ignore it, others measure snow cover patch by patch by satellite images. It may be necessary to use a variable degree-day factor in a patched snow area. If the entire area above the transient snow line is taken as snow covered, then a constant value of degree-day factor should be used. (Murphy-IVI)
W84-02828

WATER MOVEMENT INTO SEASONALLY FROZEN SOILS,
Alaska Univ., Fairbanks. Inst. of Water Resources.
For primary bibliographic entry see Field 2G.
W84-02856

MONITORING THE UNFROZEN WATER CONTENT OF SOIL AND SNOW USING TIME DOMAIN REFLECTOMETRY,
Alaska Univ., Fairbanks. Inst. of Water Resources.
For primary bibliographic entry see Field 2G.
W84-02862

RIVER ICE JAMS: THEORY, CASE STUDIES, AND APPLICATIONS,
National Water Research Inst., Burlington (Ontario).
S. Beltaos.
Journal of Hydraulic Engineering, Vol. 109, No. 10, p 1338-1359, October, 1983. 11 Fig, 2 Tab, 22 Ref.

Descriptors: *Ice jams, *Water level, *Hydraulic resistance, Hydraulic roughness, Shear stress, River flow.

The existing theory of floating ice jams in rivers was examined in the light of field data accumulated in recent years. The theory developed gradually since the late 1950's and predicts the jam thickness so that the jam, considered a granular mass, can withstand the applied forces. These forces are caused by the flow shear stress and by the streamwise component of the jam's own weight. Two types of jams have been identified: 'wide' and 'narrow' channel jams. The former type should be far more common in nature since the latter type can only exist at very small aspect ratios. The theory was tested with satisfactory outcome with available field data. Because the thickness of spring jams cannot be measured at present, the data do not permit direct estimates of the applicable roughness and internal friction characteristics. A method for arriving at such estimates indirectly, based on existing hydraulic resistance data for winter jams

of which the thickness can be measured once freezing in place has occurred to allow safe access, was applied to 13 case studies. Two methods of applying the results were outlined: a detailed method that makes use of the ice jam theory in conjunction with hydraulic resistance considerations; and a simplified method that uses the average eta versus xi relationship as defined by the data. Examples indicate that the detailed method gives better results that the simplified method. The major limitations of applying the theory to practical questions derive from the assumption of an equilibrium jam affecting fully the site of interest. This may not be the case in any given year; thus the theory can only provide an upper bound of anticipated water level as a function of discharge. (Moore-IVI)
W84-02868

ASYMMETRIC PLANE FLOW WITH APPLICATION TO ICE JAMS,
Iowa Univ., Iowa City.
For primary bibliographic entry see Field 8B.
W84-02872

2D. Evaporation and Transpiration

CARBOHYDRATE PARTITIONING IN RELATION TO WHOLE PLANT PRODUCTION AND WATER USE OF VIGNA UNGUICULATA (L.) WALP.,
Bayreuth Univ. (Germany, F.R.). Lehrstuhl fuer Pflanzenoekologie.
For primary bibliographic entry see Field 2I.
W84-02489

THE EFFECT OF DOUBLING ATMOSPHERIC CO2 ON STREAMFLOW: A SIMULATION,
Commonwealth Scientific and Industrial Research Organization, Canberra (Australia). Div. of Plant Industry.
A. R. Aston.
Journal of Hydrology, Vol. 67, No. 1-4, p 273-280, 1984. 3 Fig, 1 Tab, 23 Ref.

Descriptors: *Atmospheric carbon dioxide, *Streamflow, Computer models, Vegetation, Carbon dioxide, Air pollution effects, Agricultural hydrology, Plant water potential, Stomata, Stomatal transpiration.

There is a potential for atmospheric CO2 to rise four- or six-fold, and at some time in the forseeable future a doubling of stomatal resistance seems, on present evidence, to be inevitable. A distributed deterministic process model simulates the effects of changed stomatal resistance on streamflow of a 5 ha experimental catchment and a large (417 sq km) water-supply area. It can be expected that streamflow will increase from 40 to 90% as a consequence of doubling of atmospheric CO2 concentration. (Murphy-IVI)
W84-02898

SOIL SURFACE EVAPORATION AND WATER TABLE DEPTHS,
Florida Univ., Gainesville. Dept. of Agricultural Engineering.
S. F. Shih.
Journal of Irrigation and Drainage Engineering, Vol. 109, No. 4, p 366-376, December, 1983. 4 Fig, 3 Tab, 14 Ref. SFWMD grant 4-FCD-22.

Descriptors: *Soil surfaces, *Evaporation, *Water table, Evapotranspiration, Pan evaporation, Model studies, Water level.

The knowledge of the amount and rate of evapotranspiration is useful not only for irrigation studies but also for the development of hydrological models. The experiment was conducted in lysimeters for studying the evaporation from soil surface in relation to water table depth and standard pan evaporation. Dummy variables 1 and 0 were used as an alternative to analyze the variation and covariance to compare the soil surface evaporation difference between water table depths. The dummy variable regression analysis can simultaneously test the difference between two regression lines whether due to slope coefficients or intercept terms. The water table depth was significantly affected on the soil surface evaporation. The soil surface evaporation for 38 cm water table was significantly smaller in value than that for the 8 cm water table. The soil surface evaporation in wet season had a smaller deviation from the standard pan evaporation and had a more homogeneous distribution within the wet season than that in the dry season. (Murphy-IVI)
W84-02925

2E. Streamflow and Runoff

NORTHERN OMAN FLOOD STUDY,
Imperial Coll. of Science and Technology, London (England).
H. S. Wheater, and N. C. Bell.
Proceedings of the Institution of Civil Engineers, Vol. 75, Part 2, p 453-473, September, 1983. 11 Fig, 5 Tab, 27 Ref.

Descriptors: *Floods, *Flood frequency, *Oman, Frequency analysis, Mathematical studies, Probability distribution, Model studies, Wadi Adai, Muscat, Rainfall-runoff relationships.

A depth-duration-frequency relationship for short duration rainfall in Northern Oman was developed, based on the station-year method. The relationship is generally consistent with the frequency distribution of daily rainfall as determined from the Muscat record and with published work from a similar rainfall regime in Saudi Arabia. Analysis of flood data from the Wadi Adai gives the frequency of the storm of 3 May 1981 as between 100-300 years return period, corresponding to a peak discharge of 1160 cu m/s. Observations of the 3 May flood in the Wadi Adai were fully reproduced using a kinematic wave model based on catchment slopes and roughness for an initial loss of 8 mm and continuing runoff proportion of 0.75 for hard rock and 0.50 for gravel hill areas. Sensitivity analysis has indicated that while the overall runoff coefficient is primarily dependent on the estimated total rainfall, the distribution of losses cannot be uniquely confirmed. (Baker-IVI)
W84-02509

CAPACITY OF RIVER CHANNELS WITH FLOODPLAINS,
N. B. Baryshnikov, and E. S. Subbotina.
Hydrotechnical Construction, Vol. 17, No. 6, p 302-306, June, 1983. 3 Fig, 1 Tab, 7 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 6, p 18-21, June, 1983.

Descriptors: *Channels, *Capacity, *Flood plains, Rivers, Streamflow, River flow, Boussinesq coefficient, Coriolis coefficient, Coriolis force.

Investigations of the problem of the interaction of channel and floodplain flows revealed a substantial transformation of the velocity fields of the channel flow under the effect of the floodplain flow and of the floodplain flow under the effect of the channel flow. Therefore, to apply equations of hydraulics to a calculation of the capacity of channels with floodplains it is necessary to estimate the influence of the kinematic effect on these coefficients. In natural and artificial flows the Boussinesq and Coriolis coefficients vary in wide limits. The morphological characteristics of the river channels, the presence of midstream bars, vegetation, and the flow regime of the stream have a great effect on their values. Considerable changes in the Boussinesq and Coriolis coefficients in the channel part of the flow occur under the effect of the interaction of channel and floodplain flows. When using mean velocities instead of local velocities in calculations it is impermissible to neglect the values of the Boussinesq and Coriolis coefficients, which according to the data reported reach respectively 2-3 and 4-6. (Baker-IVI)
W84-02663

MEASURING WATER SURFACE AND STREAMBED ELEVATION CHANGES WITH THE ACOUSTIC VELOCITY METERING SYSTEM,
Geological Survey, Portland, OR. Water Resources Div.
A. Laenen.
Water Resources Research, Vol. 19, No. 5, p 1317-1322, October, 1983. 6 Fig, 1 Tab, 3 Ref.

Descriptors: *Water surface elevation, *Measuring instruments, *Acoustic velocity metering, Water depth, Streambeds, Sacramento River, California, Cowlitz River, Oregon.

Acoustic velocity metering (AVM) systems used to measure the water velocity along a diagonal path across a stream can also be used to measure stage and streambed changes. Underwater acoustic transmissions reflected from the water surface can accurately measure depth above transducers. Similarly, signals reflected from the streambed can indicate streambed changes in the vicinity midway between transducers. Surface reflected signals detected at the Sacramento River near Freeport, California, were used to calculate a water surface elevation that agreed with the observed to within 0.2%. Reflected signals from the surface have been detected at many AVM sites; however, surface conditions are not always favorable for measuring these occurrences. From May 11 to June 4, 1982, streambed elevations in the Cowlitz River at Castle Rock, Washington decreased an average of 0.6 m. Dune peaks decreased 0.7 m for this same period, while troughs decreased 1.0 m. Interpretation of oscilloscope photographs of the received pulses from the AVM equipment indicate that dune peaks decreased 0.8 m. (Baker-IVI)
W84-02771

AREAL VALUE OF DEGREE-DAY FACTOR,
Kwara State Coll. of Technology, Ilorin (Nigeria). Dept. of Survey.
For primary bibliographic entry see Field 2C.
W84-02828

SEVERAL METHODS FOR DISCHARGE MEASUREMENTS OF FLOODS,
Faculty of Civil Engineering Sciences, Split (Yugoslavia).
O. Bonacci.
Hydrological Sciences Journal, Vol. 28, No. 4, p 513-524, December, 1983. 4 Fig, 1 Tab, 15 Ref, 1 Append.

Descriptors: *Flood discharge, *Flood hydrographs, *Integrated method, Rising float method, Flow discharge, Floods.

Flow discharge measurements during floods are of considerable importance, but particularly difficult to obtain. In addition, such measurements are very expensive and often the lives of the people carrying them out are endangered. Three methods of discharge measurement during floods are described: the integrated method; discharge measurements of the total flood hydrograph; and rising float methods. Each method is suitable for a particular type of river, and the choice of method is left to the people engaged in measurements. Hydrological practice (especially in developing countries) shows that there is a significant lack of information on discharge in flood periods, and it is known that even very complex methods and precise equipment very often prove inadequate. Therefore, relatively simple measurement methods using standard equipment which make it possible to shorten the period of metering and to make contact with the river as brief as possible, are recommended. The rising float technique entirely eliminates contact between the staff and the water, and this seems to be one of the advantages governing its application in the future. (Moore-IVI)
W84-02829

THE YANGTZE RIVER; PAST, PRESENT, AND FUTURE,
Woods Hole Oceanographic Institution, MA. Dept. of Geology and Geophysics.
For primary bibliographic entry see Field 2L.
W84-02831

A METHODOLOGY FOR EVALUATION OF FLOOD FORECAST-RESPONSE SYSTEMS; 1. ANALYSES AND CONCEPTS,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 6B.
W84-02846

A METHODOLOGY FOR EVALUATION OF FLOOD FORECAST-RESPONSE SYSTEMS; 2. THEORY,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 6B.
W84-02847

A METHODOLOGY FOR EVALUATION OF FLOOD FORECAST-RESPONSE SYSTEMS; 3. CASE STUDIES,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 6B.
W84-02848

A BAYESIAN MARKOV MODEL OF THE FLOOD FORECAST PROCESS,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
R. Krzysztofowicz.
Water Resources Research, Vol. 19, No. 6, p 1455-1465, December, 1983. 10 Fig, 1 Tab, 22 Ref. NWS contract 6-35229, NSF grant CEE-8107204.

Descriptors: *Flood forecasting, *Mathematical models, Markov chain, Stochastic process, Flood hydrographs, Decision making.

One of the components of a model of the flood forecast-response process is a stochastic law Phi governing the state transitions of the flood forecast process. The law Phi describes joint uncertainty about the actual realization of the flood stage hydrograph and about the accuracy of a sequence of categorical forecasts of the flood crest. The flood forecast process is conceptualized as a discrete time, finite, random duration, bivarite Markov chain. The modeling has been accomplished via a Bayesian approach. It is the optimal approach to decision making based on real time forecasts because it allows one to explicitly account for forecast uncertainty; that is, an optimal decision should always be made against the posterior distribution of the state given the forecast of that state. It allows one to exploit all the relevant data records which typically are much longer for the flood process than for the forecast process. It lends itself ideally to dynamic programming computations (typically performed while solving Markovian decision problems) in that at any decision stage the posterior transition probabilities can be computed by applying Bayes theorem recursively, in parallel with the dynamic programming algorithm. It enhances the implementability of the model for it offers approximations to bivariate transition probability functions which require the estimation of only univariate functions. The structure of the model is motivated by an analysis of historical flood forecast records. The model is intended primarily as a component of a decision methodology for determining the economic value of and the optimal decisions in response to riverine flood forecasts. (Moore-IVI)
W84-02849

CATEGORY-UNIT LOSS FUNCTIONS FOR FLOOD FORECAST-RESPONSE SYSTEM EVALUATION,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 6B.
W84-02850

MIXED-STATION EXTENSION OF MONTHLY STREAMFLOW RECORDS,
Geological Survey, Reston, VA.
W. M. Alley, and A. W. Burns.
Journal of Hydraulic Engineering, Vol. 109, No. 10, p 1272-1284, October, 1983. 4 Fig, 2 Tab, 8 Ref, 2 Append.

Descriptors: *Streamflow records, *Interstation correlation, Multiple regression analysis, Streamflow, Mathematical studies.

Monthly streamflow records at a site are sometimes extended by exploiting interstation correlation of streamflow, often through simple linear regression with a base station having a long-term record. An approach is presented which selects a base station from among several in a region for filling in missing data. It differs from traditional approaches in that different stations can be selected as the base station to fill in different values. The approach also provides a decision rule for using only flow values from the same month or all flow values in developing the extension equation used for estimating a particular missing value. A previously presented extension equation to minimize variance bias of the flows estimated at the short-record station is shown to be applicable to this technique. The possibility of using this extension equations to adjust the results of multiple regression in order to account for variance reduction is also suggested. (Author's abstract)
W84-02864

UNIFIED THEORY FOR FLOOD AND POLLUTION ROUTING,
Vanderbilt Univ., Nashville, TN. Dept. of Civil and Environmental Engineering.
For primary bibliographic entry see Field 5B.
W84-02878

ON THE NUMERICAL SOLUTION OF THE SAINT-VENANT EQUATIONS,
Warsaw Univ. (Poland). Faculty of Geography and Regional Studies.
I. Stepien.
Journal of Hydrology, Vol. 67, No. 1-4, p 1-11, 1984. 7 Fig, 7 Ref.

Descriptors: *Power plants, *Unsteady flow, Poland, Vistula River, Saint-Venant equations, River flow, Flow discharge.

Unsteady flow below the hydropower station on the Vistula River in Poland was investigated. The implicit four-point method was used for solving the Saint-Venant equations. A 60 km reach of river with a bottom slope of 0.0002 was investigated. A diagram of the river segment and location of the control depth gauges is given. The observed range of variability of the water level did not exceed 200 cm and the corresponding variations of discharge were contained within the interval of 500-2000 cu m/sec. For such values of levels and flow rates, discharge does not exceed the values for bankfull flow and the rectangular shape of the bed may be assumed with mean width of 370 m calculated from hydrometric records for the examined river segment. Results of the numerical experiments were compared successfully with the recorded series of flow at several control depth gauges on a 60 km long branch of the Vistula River. (Baker-IVI)
W84-02882

IDENTIFICATION OF THE INPUT-OUTPUT STOCHASTIC MODEL WITH CORRELATED ERRORS,
Polish Academy of Sciences, Warsaw. Inst. of Geophysics.
W. G. Strupczewski, and R. J. Budzianowski.
Journal of Hydrology, Vol. 67, No. 1-4, p 13-23, 1984. 3 Fig, 1 Tab, 11 Ref.

Descriptors: *Hydrologic models, *Flow, *Stochastic process, *Input-output analysis, Mathematical models, Prediction, Rainfall-runoff relationships, River flow.

A stochastic discrete system approach to flow prediction is presented. The structure of the deterministic part of the model is of the ARMA type as a result of formal discretization of the continuous differential equation. The orders of the AR and MA parts are equal. The random residuals of the model are correlated and have to be modeled by a separate time series model. A model of the stochastic part is built up by means by Kalman's theorem. The maximum likelihood estimation method is applied, which results in a nonlinear optimization problem. Then the Lagrange multipler method for gradient determination and Wolfe's variable metric gradient method for this optimization are used. The model assumes a linear relation between input and output variables. The inflow-outflow relation can be treated approximately as a linear one. The stochastic part can allow in part for modelling errors. In the case of rainfall-runoff modelling or water level prediction, a stronger nonlinearity could be involved and the investigated model would fail. The developed algorithm has been applied to flow forecasting at a 30-km river reach. (Moore-IVI)
W84-02883

ENVELOPE CURVES FOR EXTREME FLOOD EVENTS IN NORTHWESTERN AND WESTERN GREECE,
National Technical Univ., Athens (Greece). Dept. of Civil Engineering.
M. Mimikou.
Journal of Hydrology, Vol. 67, No. 1-4, p 55-66, 1984. 3 Fig, 2 Tab, 7 Ref.

Descriptors: *Greece, *Flood peak, Drainage basins, Climate, Depth-area-duration analysis, Flood flow, Storms.

Maximum flood experience in the northwestern and western regions of Greece can be depicted in graphs on which the maximum observed peak discharges are plotted against drainage areas. The peak discharges are found to be power functions of the drainage areas, and the curves enveloping the plotted points differ from region to region according to the climatic regime. The exponents of the Greek envelope curves are in the range of values of the exponents of yearly floodflow-drainage area envelope curves developed in conterminous U.S. basins, but the former curves' constants are much lower than the latter. When the peak discharges are plotted against a morphoclimatic index, which is the product of the expected storm duration by the maximum observed average storm intensity for this duration by the area of the drainage basin, a single linear envelope curve is drawn for both regions that explains 95% of the regional variation in the dependent variable. This curve is free from several drawbacks of floodflow-drainage area envelope curves, i.e. it does not need the determination of region boundaries, etc. The developed envelope curves can predict peak discharges at certain probability levels for ungauged basins of the area and can be used in specific engineering applications. (Author's abstract)
W84-02885

FITTING THE SB CURVE BY THE METHOD OF MAXIMUM LIKELIHOOD,
Asian Inst. of Tech., Bangkok (Thailand).
H. N. Phien, and T. Jivajirajah.
Journal of Hydrology, Vol. 67, No. 1-4, p 67-75, 1984. 4 Tab, 8 Ref, 1 Append.

Descriptors: *Rainfall, *Streamflow, *Maximum likelihood, Method of moments, Statistical methods, Jacobean matrix, Hydrologic data, Portugal.

Newton's method was used to solve the system of nonlinear equations of which the solution are the maximum likelihood estimates of the four parameters of the S sub B curve. All elements of the related Jacobian matrix were explicitly given and suitable sums needed in the computation were introduced. A comparison was made between the methods of moments and maximum likelihood using 20 sets of annual streamflows, and 15 sets of annual rainfall data from Portugal. For annual streamflows, there were 19 cases where the method of moments was applicable. The method of maximum likelihood was applicable in only 13 out of 20 cases. Thus the method of moments is most applicable for annual streamflow data. It is also more applicable to annual rainfall data than the method of maximum likelihood. For the S sub B distribution, expressions for computing its moments are not available in closed form. When the method of maximum likelihood is used to estimate

its parameters, the useful statistical descriptions cannot be readily computed. Numerical schemes should be used and this may make the maximum likelihood method less attractive than the method of moments. (Moore-IVI)
W84-02886

ESTIMATION OF STORMFLOW VOLUMES FROM SMALL SEMI-ARID CATCHMENTS USING THE R-INDEX METHOD,
Zululand Univ., Empangeni (South Africa). Hydrological Research Unit.
A. S. Hope.
Journal of Hydrology, Vol. 67, No. 1-4, p 129-139, 1984. 1 Fig, 5 Tab, 10 Ref.

Descriptors: *Storm runoff, *Semiarid climates, *Watersheds, *R-index method, Runoff volume, Runoff rates, Cumulative runoff, Rainfall-runofff relationships, Model studies, Model testing.

The R-index method for calculating stormflow volumes was intended for use on forested and wildland catchments in the eastern U.S.A. This study calibrates the R-index model on stormflow data from three semi-arid catchments in South Africa and evaluates the performance of the method under these conditions. The R-index method is suitable for stormflow estimates in these semi-arid catchments. Parameter values for the model differ markedly to those in humid and subhumid catchments and the effect of antecedent moisture conditions on stormflow volumes is generally unimportant particularly for the larger events. The satisfactory results obtained from diverse environmental regions suggests that the model components account for the major variables affecting stormflow production. (Murphy-IVI)
W84-02890

WATERSHED MORPHOMETRY AND TIME TO HYDROGRAPH PEAK,
North Texas State Univ., Denton. Dept. of Geography.
J. M. Harlin.
Journal of Hydrology, Vol. 67, No. 1-4, p 141-154, 1984. 5 Fig, 1 Tab, 30 Ref.

Descriptors: *Watersheds, *Morphology, *Hydrographs, *Peaking capacity, Peak loads, Hypsometric analysis, Hydrograph analysis, Rainfall-runoff relationships.

Morphometric complexities often render geomorphic parameters ineffective in maintaining stable relationships over space with various aspects of hydrograph shape. Drainage density, for example, may relate either directly, or indirectly, with time-to-hydrograph peak depending upon environmental characteristics. Variations in climate, geology and degree of geomorphic development in large measure stimulate morphometric complexities. The hypsometric curve (an expression of overall basin slope) should be combined with basin area and/or relief to promote transferable hydrologic models. Three aspects of hypsometric curve form are compared to time-to-peak following intense storms in small agricultural experimental watersheds in West Virginia, Oklahoma and Vermont. A significant multiple regression-correlation relationship is forthcoming between time-to-peak and hypsometric form with no direct control for basin area, relief, relief ratio, or drainage density. Hypsometric skewness is related to headward drainage development, mid-basin slope is assessed through hypsometric density kurtosis, and the rate of change in upper and lower basin slope is quantified by hypsometric density skewness. Hypsometry should not preclude the use of other important watershed parameters, like drainage area, but hypsometric techniques might be employed along with basin area and/or relief to increase the predictive power and transferability of rainfall-runoff models. (Murphy-IVI)
W84-02891

THE EFFECT OF DOUBLING ATMOSPHERIC CO2 ON STREAMFLOW: A SIMULATION,
Commonwealth Scientific and Industrial Research Organization, Canberra (Australia). Div. of Plant Industry.
For primary bibliographic entry see Field 2D.
W84-02898

EVALUATION OF FIELD DRAINAGE DISCHARGE FROM HEAVY LAND IN THE TROPICS,
Technische Hogeschool, Delft (Netherlands). Dept. of Civil Engineering.
L. K. Smedema.
Journal of Hydrology, Vol. 67, No. 1-4, p 325-337, 1984. 5 Fig, 2 Tab, 4 Ref.

Descriptors: *Drainage, *Discharge measurement, *Heavy land, *Tropical regions, Discharge hydrographs, Soil water potential, Soil properties, Runoff volume, Surface runoff, Runoff forecasting.

Much tropical land is classified as heavy land, having a profile composed of a shallow, well-structured and well-permeable top layer of approximately 30-40 cm depth, overlying a poorly permeable subsoil. In a Tanzanian sugarcane field the drainage consisted of an in-field system of shallow ditches intercepting drainage flow in the cane furrows (row drainage). The discharge predictions of three relevant rainfall-discharge models, i.e. a linear storage model, a travelling time model (rational formula) and the curve number/synthetic unit hydrograph model of the U.S. Soil Conservation Service when compared with observed hydrographs produce good agreements with the linear storage model although, in this case, the linearity between discharge rate (q) and dynamic storage (S) appeared to be somewhat incidental, being promoted by the particular row drainage layout of the field. (Murphy-IVI)
W84-02901

BRASS MODEL: PRACTICAL ASPECTS,
Army Engineer District, Savannah, GA.
For primary bibliographic entry see Field 7B.
W84-02921

COMPUTATIONAL MODEL FOR THE OHIO RIVER CHUTES AT LOUISVILLE: THE 1972 VIRGIN CONDITIONS,
For primary bibliographic entry see Field 7C.
W84-02932

2F. Groundwater

PATTERNS IN GROUNDWATER QUALITY: SELECTED OBSERVATIONS IN IOWA,
Iowa Univ., Iowa City. Dept. of Geology.
For primary bibliographic entry see Field 5G.
W84-02644

THE INTERACTION OF LAKES WITH VARIABLY SATURATED POROUS MEDIA,
Geological Survey, Denver, CO.
T. C. Winter.
Water Resources Research, Vol. 19, No. 5, p 1203-1218, October, 1983. 9 Fig, 38 Ref.

Descriptors: *Groundwater movement, *Lakes, *Porous media, *Saturation, Groundwater recharge, Seepage, Surface water, Infiltration, Simulation, Aeration zone.

Numerical simulation of variably saturated porous media indicates that groundwater recharge is variable in time and space, depending on the thickness of the unsaturated zone through which infiltrating water must move. The resulting complex, transient groundwater flow systems have significant impact on contiguous surface water. In very permeable media, small, local, closed groundwater flow systems can develop and dissipate within a few weeks to several months after major recharge. These have a direct effect on contiguous surface water by alternately causing seepage to and seepage from the surface water. The transient nature of these flow systems indicates that reversals of the direction of groundwater flow may be common. In less permeable media the same complex flow systems may occur, but the time for development and dissipation is much greater. For example, it is conceivable that small, local flow systems may exist for many months or years as a result of major recharge. Therefore directions of flow in such systems are more stable, and the effect on contiguous surface water also is more stable. The findings of this study indicate that wells and groundwater quality sampling sites need to be carefully located to define accurately water table configuration, groundwater recharge, direction of seepage through the beds of surface water bodies, and complex geochemical processes related to changing directions of groundwater flow. (Author's abstract)
W84-02764

SOME NEW PROCEDURES FOR NUMERICAL SOLUTION OF VARIABLY SATURATED FLOW PROBLEMS,
Geological Survey, Denver, CO.
R. L. Cooley.
Water Resources Research, Vol. 19, No. 5, p 1271-1285, October, 1983. 12 Fig, 27 Ref, 1 Append.

Descriptors: *Groundwater movement, *Saturated flow, *Unsaturated flow, *Mathematical models, Computer models, Seepage surfaces.

Persistent difficulties that arise in forming numerical solutions of variably saturated flow problems include controlling the stability of the nonlinear equation solvers and devising a reliable, yet efficient, method for determining the positions of seepage surfaces. New techniques for addressing these problems are applied to a subdomain finite element discretization of the governing flow equations. The subdomain finite element method used produces accurate results, and has an added advantage over finite difference methods of accomplishing a greater amount of nodal averaging of troublesome nonlinear quantities to improve stability. New procedures for solving the nonlinear matrix equation that results from the finite element method and for locating the positions of seepage faces are capable of solving a wide variety of variable saturated flow problems. (Moore-IVI)
W84-02768

SUBSURFACE ORGANIC CONTAMINANTS,
For primary bibliographic entry see Field 5B.
W84-02792

MAJOR ION CHARACTERIZATION OF COASTAL SALINE GROUND WATERS,
Toronto Univ. (Ontario). Dept. of Geology.
K. W. F. Howard, and J. W. Lloyd.
Ground Water, Vol. 21, No. 4, p 429-437, July-August, 1983. 4 Fig, 3 Tab, 17 Ref.

Descriptors: *Groundwater movement, *Saline water, *Coastal aquifers, *Ions, England, Lincolnshire, Humberside, Dilution diagrams, Saline water intrusion, Mixing.

Attempts to classify saline groundwaters in coastal aquifers using established trilinear diagram techniques are frequently inconclusive due largely to the dominance of sodium and chloride ions. In a study of saline ground waters from the Chalk limestone of Lincolnshire and Humberside in eastern central England, an alternative, less conventional, dilution diagram procedure is employed which reveals previously unrecognized differences in local major ion chemical character. Differences are interpreted in terms of the origins of the saline ground waters and their histories of mixing. Significantly, the interpretations reinforce and, in some cases, refine earlier interpretations based on notably less extensive minor ion and environmental isotope data. The saline ground waters are associated with at least three periods of saline intrusion during the past 120,000 years. Two of the groundwater types are shown to be old by virtue of their mixing relationships that cannot be reconciled fully in terms of local fresh groundwater end-points. A third, modern water type shows strong evidence of reverse ion exchange, which is consistent with modern saline groundwater invading parts of an

aquifer that had previously provided an outlet for calcium-rich waters. (Moore-IVI)
W84-02803

AQUIFER TESTS AND WELL FIELD PERFORMANCE, SCIOTO RIVER VALLEY OHIO: PART II,
S. E. Norris.
Groundwater, Vol. 21, No. 4, p 438-444, July-August, 1983. 2 Fig, 1 Tab, 11 Ref.

Descriptors: *Aquifer testing, *Test wells, Wells, Aquifers, Water supply management, Scioto River, Ohio, Rivers, Permeability coefficient, Hydrology.

The aquifer testing program as described has offered a unique opportunity to determine the hydrologic properties of an important sand and gravel aquifer at 11 closely spaced sites. Significant data were acquired on variation in hydraulic conductivity of the sand and gravel aquifer and characteristics of induced stream infiltration. It has also been possible to compare recommendations for well design, made on the basis of the aquifer testing, with results of operation of a major well field. The sand and gravel aquifer studied is south of the glacial boundary and is fairly homogeneous, due largely to the absence of till interbeds. Nevertheless, test drilling revealed extensive areas where the sediment were considered too poorly permeable to warrant hydraulic testing. At the sites tested, where the sediments seemed favorable for developing supply wells, the transmissivity and also the hydraulic conductivity, when averaged over the full saturated thickness, differed by 2.4 times. The stream infiltration rate differed by 2.8 times and the streambed leakage factor differed by 15 times between highest and lowest values. Neither the infiltration rate values, nor those of the streambed-leakage factor, when considered in toto, correlated sensibly with stream discharge. The poor correlation between the hydraulic conductivity of the streambed and stream discharge suggests that there may be little variation in streambed conductivity caused by streamflow changes over the range of discharges observed during the tests. (Baker-IVI)
W84-02804

FLOW PATTERN OF A KARST AQUIFER IN THE MOLAI AREA, GREECE,
Ministry of Agriculture, Athens (Greece). Directorate of Land Reclamation.
I. C. Ghikas, G. P. Kruseman, I. L. Leontiadis, and D. H. Wozab.
Ground Water, Vol. 21, No. 4, p 445-454, July-August, 1983. 5 Fig, 5 Tab, 9 Ref.

Descriptors: *Aquifers, *Flow pattern, Groundwater movement, Greece, Molai Plain, Karst, Karst hydrology, Carbonates, Gulf of Lakonia, Water quality, Tectonics.

Geological, hydrological, hydrochemical, isotope, and pumping test data of the karst aquifer in the Mesozoic Tripolitza carbonates of the Molai area were analyzed. Two flow systems were identified in the carbonates. The western system discharges through the shore and submarine at Glyfada into the Gulf of Lakonia. Its catchment, which has no exploitable reservoir, is connected to the springs by a narrow conduit related to a fracture zone in marbles that accompany the Molai fault. Along the northern frings of the Molae Plain is the eastern flow system which has a reservoir with acceptable pumping levels less than 120 m deep. The water quality of this system is variable. The system discharges into the Aegean Sea, probably through dispersed seepage flow. The unusual characteristics of the karst in the Molai area can be explained by the continuous tectonic activity which has prevented the completion of various stages of karst development. The Molai area possesses the general characteristics of the Mediterranean climate: mild, wet winters, and moderately hot, dry summers. Nearly all precipitation falls in the form of rain from October-March with a peak in January. The long-term average annual precipitation in the carbonate area is about 670 mm. The tectonic activity continually interrupted the sequence of the karst formation, but also caused an extremely dense fracturing. Thus infiltration was evenly spaced over the carbonate outcrops, and vertical pipes had only occasionally developed in places where concentrated infiltration occurred. Horizontal pipes and caves never had a chance to develop fully. (Baker-IVI)
W84-02805

GROUND-WATER FLOW MODEL DETERMINATIONS OF AREAL HYDROGEOLOGY AND GEOLOGY,
Wisconsin Univ.-Madison. Dept. of Geology and Geophysics.
D. F. E. Pennequin.
Ground Water, Vol. 21, No. 5, p 552-557, September-October, 1983. 3 Fig, 2 Tab, 11 Ref.

Descriptors: *Groundwater movement, *Model studies, Wisconsin, Lake Wingra, Permeability coefficient, Anisotrophy, Sediments, Aquifers, Hydrogeology, Mathematical models.

A two-dimensional model is presented which closely simulates groundwater flow in a specific cross section of an area near Lake Wingra, Wisconsin. The model allows determination of the important hydrogeologic parameters needed to calculate the groundwater budget for Lake Wingra, and demonstrates the importance of groundwater flow models as tools that can be used in conjunction with other calculations to help estimate the groundwater component of a lake's water budget. In addition to gaining hydrogeologic information, this study suggests that by using groundwater flow models, it is possible to reconstitute the general subsurface geology and the configuration of geologic contacts in a fairly simple geologic setting, provided that some information on the geology, reliable hydaulic head measurements for different depths into the aquifer system, and a general knowledge of the horizontal hydraulic conductivities are available. (Baker-IVI)
W84-02808

ANALYSIS OF FLOW TO A LARGE-DIAMETER WELL BY A DISCRETE KERNEL APPROACH,
Baroda Univ. (India). Dept. of Civil Engineering.
S. C. Patel, and G. C. Mishra.
Ground Water, Vol. 21, No. 5, p 573-576, September-October, 1983. 4 Fig, 1 Tab, 15 Ref.

Descriptors: *Groundwater movement, *Wells, Drawdown, Discrete kernel approach, Mathematical studies, Aquifer properties.

A discrete kernel approach has been used to analyze unsteady flow to a large-diameter well, taking well storage into consideration. Several assumptions to the solution were made: the well discharges at a constant rate; at any time the drawdown in the aquifer at the well face is equal to that in the well; and the time parameter is discrete so that within each time step, the abstraction rate of water derived from well storage and that from aquifer storage are separate constants. The drawdown at the well obtained by this approach compares favorably with the drawdown evaluated by Papadopulos and Cooper's solution (Water Resources Research, Vol. 3, No. 1, p 241-244, 1967). The discrete kernel approach is simple and does not involve large computations. However, it cannot be applied for a large diameter well in an unconfined aquifer for it is applicable only for a linear system and the coefficients of the method are evaluated, assuming a constant transmissivity of the aquifer. (Baker-IVI)
W84-02810

REGIONAL TRENDS IN TRANSMISSIVITY AND HYDRAULIC CONDUCTIVITY, LOWER CRETACEOUS SANDS, NORTH-CENTRAL TEXAS,
Texas Univ. at Austin.
G. L. Macpherson.
Ground Water, Vol. 21, No. 5, p 577-583, September-October, 1983. 14 Fig, 1 Tab, 11 Ref. DOE contract DE-AS07-79ID12057.

Descriptors: *Aquifer properties, *Permeability coefficient, *Transmissivity, Sandstone, Balcones-Ouachita, Texas, Woodbine aquifer, Paluxy aquifer, Hosston/Trinity aquifer, Pumping tests.

Regional trends in aquifer properties can be deduced from a combination of pumping-test and performance-test data. Histograms show that the range and frequency distribution of estimated transmissivities in the Hosston/Trinity, the aquifer with the largest areal extent and the most data, are similar to the range and frequency distribution of pumping-test tansmissivities. Although there are fewer pumping tests in the Paluxy and Woodbine, the frequency distribution of estimated transmissivities in these aquifers is similar to that of transmissivities in the Hosston/Trinity, suggesting that, because the depositional histories of the aquifers are somewhat comparable, the estimated transmissivities are probably valid representations of actual transmissivity. In the Hosston/Trinity study area, transmissivity generally increases basinward as the aquifer increases in thickness, although the hydraulic conductivity decreases, an indication of a decrease in sediment size or degree of sorting. In the Paluxy aquifer, both transmissivity and hydraulic conductivity increase somewhat toward the basin, which may imply that diagenesis has enhanced hydraulic conductivity in the basin ward parts of the aquifer or that the grain size is larger or that sorting is better. In the Woodbine aquifer, although the deposition axis is nearly normal to that of the other formations, the relationships are similar to those of the Paluxy aquifer. (Baker-IVI)
W84-02811

UPDATED RADIOISOTOPE STUDIES IN ZIMBABWEAN GROUND WATERS,
Ministry of Water Development, Salisbury (Zimbabwe). Hydrological Branch.
P. Wurzel.
Ground Water, Vol. 21, No. 5, p 597-605, September-October, 1983. 8 Fig, 3 Tab, 12 Ref.

Descriptors: *Groundwater, *Water supply, Zimbabwe, Sabi Valley, Alluvial plains, Reservoirs, Radioactive tracers, Potentiometry, Boreholes, Geohydrology.

The groundwater hydrology of the Sabi Valley alluvial plain, the largest tract of alluvium in Zimbabwe, was studied by three independent methods: the classical approach of potentiometric surface construction and pump test analyses, the use of in-borehole velocity and direction measurements with artificial radioactive isotopes applied to the point-dilution techniques, and a natual and thermonuclear tritium survey. The three methods of approach produced remarkably close values for the groundwater throughflow within the plain. In terms of the physical size of the basin and thus amount of water stored, the following values exist: mean aquifer thickness of 40 m, mean porosity of 15%, and an areal extent of the aquifer of 300 sq km, producing a storage volume of 2 x 10 to the 9th power cu m. However, it is usual in confined aquifers to assign greater weight to the rate concept when discussing safe yield, in which case the safe yield of 2.6 m/sec is currently based on evidence from three independent techniques, and is used for the planning of conjunctive utilization of ground water and surface water. (Baker-IVI)
W84-02812

EFFECTS OF AQUIFER INTERCONNECTION RESULTING FROM UNDERGROUND COAL GASIFICATION,
Lawrence Livermore National Lab., CA.
R. Stone, E. Raber, and A. M. Winslow.
Ground Water, Vol. 21, No. 5, p 606-618, September-October, 1983. 15 Fig, 2 Tab, 14 Ref.

Descriptors: *Aquifer system, *Environmental effects, *Coal gasification, Powder River Basin, Wyoming, Groundwater movement, Permeability coefficient, Flow patterns.

The effects of aquifer interconnection caused by the collapse of cavities formed in coal seams by two small underground coal gasification experiments in the Powder River Basin, Wyoming were explored. The magnitude and extent of changes in

groundwater flow patterns near the site of the experiments were measured. A steady state groundwater flow model of the interconnection zone at each site was constructed using hydraulic head measurements in the three affected aquifers. Water from one or both of the upper aquifers entered the collapse rubble and flowed down to the lowest aquifer (the gasified coal seam) where it flowed away from the collapse zones. The hydraulic conductivity of the collapse rubble is less than that of the aquifers and provides only a very moderately permeable interconnection between them. A marked reduction in the hydraulic conductivity of the gasified coal seam near the collapse zones causes restriction of flow in the seam, away from them. Changes in hydraulic head and flow patterns caused by aquifer interconnection extend generally only 200-300 ft (60-90 m) away from the experiment sites. Flow in the uppermost aquifer at one of the sites may be influenced as far as 400 ft (122 m) away. At both experiment sites, aquifer interconnection allows water from the uppermost (sand) aquifer, which contains the poorest quality water of the three aquifers, to enter one or both of the underlying coal aquifers. (Baker-IVI)
W84-02813

AN APPLICATION OF GEOSTATISTICS TO DETERMINE REGIONAL GROUND-WATER FLOW IN THE SAN ANDRES FORMATION, TEXAS AND NEW MEXICO,
Texas Univ. at Austin. Bureau of Economic Geology.
E. D. Orr, and A. R. Dutton.
Ground Water, Vol. 21, No. 5, p 619-624, September-October, 1983. 6 Fig, 15 Ref.

Descriptors: *Groundwater movement, *Statistical methods, *San Andres Formation, *Texas, *New Mexico, Geologic mapping, Hydraulic head, Kriging.

Problems were encountered during attempts to construct a contour map of hydraulic head for groundwater in the San Andres Formation in west Texas and eastern New Mexico. Variability in quality and distribution of data were responsible for some of the difficulties. Only in the northern part of the study area can the direction of regional groundwater flow be inferred from raw data where reliable drill-stem tests and water level measurements make up most of the data. Unreliable and highly variable drill stem tests comprise the bulk of the data in the southern area. Variogram analysis and kriging successfully remove the effects of high measurement error, allowing the regional trend to be seen. However, kriged block estimates could not be computed for a critical region with sparse data in the northeastern part of the study area. The most complete potentiometric surface can be contoured from hybrid data: kriged block estimates from the southern region, and original head measurements in the northern region. (Baker-IVI)
W84-02814

HEAT CONVECTION IN WARM SPRINGS VALLEY, VIRGINIA,
ERTEC, Inc., Long Beach, CA.
A. P. Severini, and D. Huntley.
Ground Water, Vol. 21, No. 6, p 726-732, November-December, 1983. 9 Fig, 21 Ref.

Descriptors: *Hot springs, *Convection, *Groundwater, *Warm Springs Valley, *Virginia, Water temperature, Permeability, Geohydrology.

The importance of free and forced convection on the occurrence of hot springs in Warm Springs Valley, Virginia, was investigated. Hydrogeologic controls were established on the convection system and it was determined whether or not, using a normal geothermal gradient and measured hydrogeologic parameters, convection alone could account for spring temperatures on the order of 40 degrees C. Standard field hydrogeologic investigation techniques with a two-dimensional numerical model of a cross section of the Warm Springs Valley system were used. In order to produce the observed groundwater temperatures in the discharge areas ground water must circulate to depths of about 5 km, must have a vertical zone of enhanced permeability in the discharge area, must have a horizontal zone of enhanced permeability near the 5 km depth of circulation, and should have relatively low permeabilities in the recharge area. All of these constraints are compatible with the geology found in the Warm Springs Valley area. (Baker-IVI)
W84-02818

GROUND-WATER MODELING IN A SOUTHWESTERN ALLUVIAL BASIN,
Hargis and Montgomery, Inc., Tucson, AZ.
D. B. Hawkins, and D. B. Stephens.
Ground Water, Vol. 21, No. 6, p 733-739, November-December, 1983. 14 Fig, 17 Ref.

Descriptors: *Groundwater movement, *Model studies, Alluvial basins, Animas Valley, New Mexico, Computer models, Kriging, Water level, Transmissivity.

A groundwater flow system in an alluvial basin in Animas Valley, New Mexico was modeled using a two-dimensional finite-difference computer code. The transmissivity distribution for the model was determined using a three-step approach. First, values of the nature logarithm of transmissivity were interpolated from existing data using the kriging technique. This interpolation scheme also produced a map of standard deviations of the kriging errors. Secondly, a conventional flow net was drawn from steady state water levels with the aid of the kriged hydraulic head distribution. Thirdly, the approximate transmissivity map, the standard deviation map of the kriged log of transmissivity values, and flow net were used to select the segment of each stream tube where transmissivity was known with the greatest certainty. Then, transmissivities in other segments of the stream tubes were calculated from Darcy's Law. This distribution, when input to the numerical model, did not have to be altered appreciably during the calibration for a steady state and seven year transient period. Most of the transient calibration was accomplished by adjusting storage coefficients. Considering the uncertainity in the available pumping data, very good agreement was found between observed and predicted water levels during a four year model verification period, in spite of likely errors in total pumpage and the approximate methods used to assign pumping rates. (Baker-IVI)
W84-02819

EXPERIMENTAL STUDY OF SOME HYDROGEOPHYSICAL PROPERTIES OF UNCONSOLIDATED POROUS MEDIA,
Consiglio Nazionale delle Ricerche, Milan (Italy). Ist. per la Geofisica della Litosfera.
G. Biella, A. Lozej, and I. Tabacco.
Ground Water, Vol. 21, No. 6, p 741-751, November-December, 1983. 10 Fig, 3 Tab, 42 Ref.

Descriptors: *Aquifer characteristics, *Porous media, Permeability, Porosity, Natural waters, Sand, Particle size.

One- and two-component artificial sand samples were used to estimate the relations between formation factor, porosity, and permeability. Determinations of formation factor values with different porewater resistivity for different samples indicated that under these experimental conditions the measured formation factor approaches the intrinsic formation factor. The relationship between intrinsic formation factor and porosity does not depend on grain size and size distribution. In the range between 100 and 40% of the small component, both porosity and permeability in the two-component samples decrease with the small-component percentage; while porosity is independent of grain size, permeability values are strictly controlled by the small component size which dominates the structure of the assemblage. When studying natural formations with clean sand, the general conclusions are very different and particularly the size distribution is more complex. In this case it seems to be at least necessary to determine a mean grain size value corresponding to the effective size, and measure or estimate a value approaching the intrinsic formation factor by making the suitable corrections. (Baker-IVI)
W84-02820

GROUNDWATER RECHARGE ESTIMATES FOR TWO BASINS IN THE DECCAN TRAP BASALT FORMATION,
National Geophysical Research Inst., Hyderabad (India).
R. N. Athavale, R. Chand, and R. Rangarajan.
Hydrological Sciences Journal, Vol. 28, No. 4, p 525-538, December, 1983. 6 Fig, 5 Tab, 10 Ref.

Descriptors: *Groundwater recharge, *Monsoons, *Deccan Trap, Kukadi basin, Godavari-Purna basin, India, Tritium, Water level fluctuations, Evaporation, Percolation.

Recharge to phreatic aquifers in the Deccan Trap basalt formation due to 1980 precipitation was determined in the Kukadi and Godavari-Purna basins (India) by tritium injection. Tritium was injected in June 1980, just before the onset of monsoon, at a depth of 60 cm; vertical soil profiles were collected after the monsoon and also at the end of the hydrological year, i.e. in May 1981. Laboratory measurements of variation in moisture percentage and tritium concentration with depth were used in estimation of recharge. Recharge values for 19 sites in Kukadi basin varied from 135 to -8 mm while those for 24 sites in Godavari-Purna basin varied from 208 to -28 mm, giving mean values as 46 and 56 mm respectively. Annual input to the groundwater reserves of the two basins was calculated as 31.9 and 35.4 million cu m respectively. A qualitative correlation between recharge values and water level fluctuation data for dug wells was observed and a reasonable agreement with hydrogeological estimates of recharge was also found. The effect of evaporation in dry summer months on moisture in the deep percolation zone was evaluated through comparison of post-monsoon 1980 and pre-monsoon 1981 recharge values. (Author's abstract)
W84-02830

ESTIMATION OF GROUNDWATER RECHARGE PARAMETERS BY TIME SERIES ANALYSIS,
Geological Survey, Denver, CO.
R. L. Naff, and A. L. Gutjahr.
Water Resources Research, Vol. 19, No. 6, p 1531-1546, December, 1983. 22 Fig, 3 Tab, 17 Ref, 2 Append.

Descriptors: *Time series analysis, *Groundwater recharge, Precipitation, Dupuit aquifers, Water level fluctuations, Effective precipitation, Mathematical models.

A model is proposed that relates water level fluctuations in a Dupuit aquifer to effective precipitation at the top of the unsaturated zone. Effective precipitation, defined as that portion of precipitation which becomes recharge, is related to precipitation measured in a nearby gage by a two-parameter function. A second-order stationary assumption is used to connect the spectra of effective precipitation and water level fluctuations. Measured precipitation is assumed to be Gaussian, in order to develop a transfer function that relates the spectra of measured and effective precipitation. A nonlinear least squares technique is proposed for estimating parameters of the effective-precipitation function. Although assumptions of Gaussian precipitation and of a constant loss factor are restrictive, results from the case studies show that the procedure yields reasonable results that are acceptable, as indicated by the overall small model variances of the case studies. One problem is sensitivity to both form and scale of the covariance function used for precipitation. Consequently, identification of the appropriate covariance type is an important factor for use of the method. The loss factor is the more sensitive parameter to estimate of the two parameters studied. It has a greater variability and is more likely to be misestimated. (Moore-IVI)
W84-02855

SLUG TESTS IN FISSURED AQUIFERS,
Institute of Geological Sciences, Edinburgh (Scotland).
J. A. Barker, and J. H. Black.
Water Resources Research, Vol. 19, No. 6, p 1558-1564, December, 1983. 4 Fig, 1 Tab, 12 Ref.

Descriptors: *Slug tests, *Fissured aquifers, Transmissivity, Storage coefficient, Estimation, Aquifer testing, Mathematical models.

A simple model of a slug test in a fissured aquifer has been studied in order to gain insight into the difficulties of interpreting data from such tests. The model is used to estimate the errors that would result from applying the standard type curve analysis to fissured aquifers. It is found that the derived aquifer transmissivity will always be overestimated, but by a factor which is unlikely to exceed 3. By contrast, the derived storage coefficient can be in error by a factor ranging from 10 to the -6th to 10 to the 5th. The volume of the aquifer influenced by a slug test is investigated, and a simple formula for estimating the range of a test is suggested. (Author's abstract)
W84-02861

GEODETIC EVIDENCE FOR SUBSIDENCE DUE TO GROUNDWATER WITHDRAWAL IN MANY PARTS OF THE UNITED STATES OF AMERICA,
Cornell Univ., Ithaca, NY. Dept. of Geological Sciences.
S. C. Chi, and R. E. Reilinger.
Journal of Hydrology, Vol. 67, No. 1-4, p 155-182, 1984. 10 Fig, 2 Tab, 69 Ref. NASA grant NAG5-40, USGS grant 14-08-0001-17625.

Descriptors: *Geodetics, *Subsidence, *Groundwater recession, Groundwater depletion, Groundwater level, Consolidation sedimentation, Tectonics, Uplift pressure.

Analysis of repeated levelings conducted by the National Geodetic Survey indicates many locations of relative subsidence in the U.S.A. Specific criteria are used to identify those subsidence features which most likely result from sediment compaction due to lowering of water levels in underground aquifer systems. Previously reported areas of such subsidence include: south-central Arizona; Savannah, Georgia; Pecos and Houston-Galveston, Texas; Denver, Colorado; San Joaquin Valley, Santa Clara Valley, Saugus Basin, Los Angeles Basin and Bunker Hill-San Timoteo, California; Milford, Utah; Raft River Valley, Idaho; Baton Rouge and New Orleans, Louisiana; and Las Vegas, Nevada. Analysis indicates that such subsidence is more widespread than previously reported occurring in a number of locations within the Atlantic and Gulf of Mexico coastal plains and along the Mississippi Valley as well as in many other unconsolidated sedimentary basins from which groundwater has been extracted and for which repeated leveling measurements are available. Identified are more than 30 new locations of subsidence possibly due to water withdrawal. The best documented of these include: Ventura, Ontario and San Pedro-Santa Monica, California; Monroe and Alexandria, Louisiana, and Jackson, Mississippi. Subsidence in newly identified locations ranges from several tens of millimeters to a few hundred millimeters over distances of approximately 10-60 km and times of 2-48 yr. Subsidence may also have occurred in other groundwater basins where water levels have been drawn down, and remained undetected because of a lack of repeated levelings. It is important to be aware of and to continue to monitor such effects because of increasing rates of utilization of groundwater resources and the potential for significant engineering problems due to surface movements. In addition, identifying cases of subsidence due to water withdrawal is essential in order to use effectively releveling observations for investigating tectonic deformation. Along these lines, the analysis suggests that some of the releveling observations used to define a region of tectonic uplift in southern California more likely reflect subsidence due to water-level declines within sedimentary basins around the periphery of the presumed zone of uplift. (Murphy-IVI)
W84-02892

THE CAPILLARY FRINGE AND ITS EFFECT ON WATER-TABLE RESPONSE,
Waterloo Univ. (Ontario). Dept. of Earth Sciences.
R. W. Gillham.
Journal of Hydrology, Vol. 67, No. 1-4, p 307-324, 1984. 12 Fig, 14 Ref.

Descriptors: *Capillary fringe, *Water table, Water table fluctuations, Moisture tension, Groundwater recharge, Capillary capacity, Capillary conductivity, Water table rise.

Shallow water tables are often observed to respond in a highly disproportionate manner to precipitation events. That is, the magnitude of the response is often much greater than would be predicted on the basis of the specific yield of the geologic material and the amount of rainfall. If the capillary fringe (the zone of tension saturation) extends to ground surface, then the addition of a very small amount of water can result in an immediate and large rise in the water table. A field experiment in which the addition of 0.3 cm of water caused the water table to rise 30 cm in 0.25 min. supports the arguments, thus demonstrating the large and highly transient influence of the capillary fringe on the position of the water table. The capillary-fringe effect could have a major influence on the process of streamflow generation, contaminant transport to surface waters and contaminant transport in hydrogeologic regimes having shallow water tables. The calculations of groundwater recharge and consumptive use, based on water-table response and an assumed specific yield, could be substantially in error. (Murphy-IVI)
W84-02900

SOIL SURFACE EVAPORATION AND WATER TABLE DEPTHS,
Florida Univ., Gainesville. Dept. of Agricultural Engineering.
For primary bibliographic entry see Field 2D.
W84-02925

2G. Water In Soils

SOIL MOISTURE INFLUENCE ON MICRONUTRIENT CATION AVAILABILITY UNDER AEROBIC CONDITIONS,
Texas Agricultural Experiment Station, College Station.
A. I. Adam, and W. B. Anderson.
Plant and Soil, Vol. 72, No. 1, p 77-83, 1983. 3 Fig, 2 Tab, 17 Ref.

Descriptors: *Soil water, *Micronutrients, *Aerobic conditions, Microorganisms, Copper, Iron, Manganese, Zinc, Climate, Sudan.

The three major soils series comprising the Gezira scheme (Sudan) are Hosh, Suleimi, and Laota. Surface soil samples from each soil series were employed to study the effect of soil moisture on the DTPA-extractable micronutrient cation under aerobic conditions. The study continued for 8 weeks using an incubation technique at two levels of soil moisture (continuously moist and moist/dry cyles). The DTPA-extractable Cu, Fe, Mn and Zn from air-dry soil samples were much higher compared to values from their incubated counterparts. For the three soils the CO2 production (microbial activity) reached the maximum in 5 weeks and then levelled off while the lowest values of micronutrient cation from the incubated soils were obtained between 2 to 8 weeks. (Author's abstract)
W84-02503

SORPTION PROCESSES IN SOILS AS INFLUENCED BY PORE WATER VELOCITY: 2. EXPERIMENTAL RESULTS,
Oregon State Univ., Corvallis. Dept. of Soil Science.
S. Akratanakul, L. Boersma, and G. O. Klock.
Soil Science, Vol. 135, No. 6, p 331-341, June, 1983. 9 Fig, 6 Tab, 3 Ref.

Descriptors: *Interstitial water, *Cadmium, *Soil water, *Adsorption, Interstitial water velocity, Diffusion, Soil solution.

Experiments were carried out to measure the rate of adsorption of cadmium for static and dynamic flow conditions. The water content of samples was maintained at -12.6 kPa, corresponding to 87% of saturation. Adsorption rates at apparent pore water velocities (v) of 1.3, 2.3, and 2.7 cm/h were measured. Diffusive conductance, Kd, and forward (k1) and backward (k2) rate constants were calculated using the Nelder-Mead Simplex method based on a nonlinear least-square procedure. Values of Kd and of the ratio k1/k2 increased with increasing pore water velocity. The rate of adsorption was higher in a sample with solution flowing through it than in a sample with the same solution under static conditions. The magnitude of Kd ranged from 0.00007 at static conditions to 0.0004/s with v = 2.7 cm/h. Results imply that the thickness of the subsurface layer decreases with v, thus increasing the diffusion rate of ions across this layer. When the adsorption process is far from equilibrium, diffusion across the subsurface layer became a rate-limiting step in the adsorption process. Lateral diffusion cannot be ignored in studies of the kinetics of adsorption. The increase in values of k1/k2 with increasing v indicates that the surface reaction proceeded at a more rapid rate in the presence of a continuous supply of solution. Flowing solution serves as a continuous source of the introduced ions, as well as a continuous sink for the desorbed ions of other species originally present. The accelerated rate of adsorption induced by flow of solution through the soil may be attributed both to an increase in the rate of diffusion as the thickness of the subsurface layer decreases and to an increase in rate of the kinetic reactions at the surface as the exchange process proceeds in the presence of the continuous sink. (Authro's abstract)
W84-02514

COMPARISON OF SOIL WATER INFILTRATION PROFILES OBTAINED EXPERIMENTALLY AND BY SOLUTION OF RICHARDS' EQUATION,
Michigan State Univ., East Lansing. Dept. of Crop and Soil Sciences.
R. J. Kunze, and D. R. Nielsen.
Soil Science, Vol. 135, No. 6, p 342-349, June, 1983. 2 Fig, 3 Tab, 14 Ref.

Descriptors: *Infiltration, *Soil water, Permeability coefficient, Diffusivity, Water content, Wetting, Mathematical studies.

Hesperia and Columbia soil experimental infiltration data are compared to calculated profiles obtained by solutions of Richards' equation requiring soil water diffusivity D and hydraulic conductivity K as functions of the water content theta. The calculations were made using a finite-difference, iterative method (FINDIT). Predicting wetting profiles by this method is somewhat more rigorous than some other solutions of Richards' equation. The method reduces calculations for infiltration to a two-term algebraic equation, partitions infiltration into matric and gravitational components, and gives an asymptotic relationship between the infiltration rate and the saturated conductivity as time approaches infinity. An array of solutions for the two indicated soils, obtained with and without the diffusion lip procedure, raises questions of the need for its use. A new method for estimating the lambda - theta area in horizontal infiltration analysis, using only diffusivity data, gives estimates to less than 3% of the final value. Integrated mean values of D and K were required for accurately predicting soil moisture wetting profiles over a range of time periods and theta divisions. Arithmetic and geometric means and nonaveraged values, particularly of D, produced unreliable wetting profiles. (Author's abstract)
W84-02515

CULTIVATION AND EVAPORATIVITY EFFECTS ON THE DRYING PATTERNS OF SANDY LOAM SOIL,
Punjab Agricultural Univ., Ludhiana (India). Dept. of Soils.
For primary bibliographic entry see Field 3F.
W84-02516

A REEXAMINATION OF THE CONSTANT HEAD WELL PERMEAMETER METHOD FOR MEASURING SATURATED HYDRAULIC CONDUCTIVITY ABOVE THE WATER TABLE,

Guelph Univ. (Ontario). Dept. of Land Resource Science.
W. D. Reynolds, D. E. Elrick, and G. C. Topp.
Soil Science, Vol. 136, No. 4, p 250-268, October, 1983. 1 Fig, 3 Tab, 19 Ref.

Descriptors: *Permeability coefficient, *Soil saturation, Permeameters, Hydraulic pressure, Steady-state flow, Wells, Estimation, Mathematical analysis.

Although the constant head well permeameter method for field measurement of field-saturated hydraulic conductivity above the water table has several advantages over other methods. it has not been widely used due to a tendency to underestimate hydraulic conductivity relative to other methods. A theoretical analysis of steady-state flow out of a well situated above the water table reveals that the underestimation is at least partially due to the inaccurate analytical solution used to approximate the vertical and horizontal hydraulic pressure gradient distributions along the wall and base of the well. Derivation of a more accurate analytical approximation of the gradient distributions resulted in an increase in the hydraulic conductivity estimate of about 40% and a numerical approximation of the gradient distributions resulted in an increase of 60%. Using the numerical solution, the constant head well permeameter method produced estimates of the saturated conductivity of a structureless sandy soil that were statistically equivalent to the estimates produced by the air entry permeameter method. This improvement thus eliminates, at least within the limits of the tests, the previous tendency of the constant head well permeameter method to underestimate the hydraulic conductivity. The improvements in practical application, which result from refinements in apparatus design, increase the efficiency and range of operation of the method. (Moore-IVI)
W84-02519

A STOCHASTIC ANALYSIS OF MACROSCOPIC DISPERSION IN FRACTURED MEDIA,

Alberta Univ., Edmonton. Dept. of Geology.
F. W. Schwartz, L. Smith, and A. S. Crowe.
Water Resources Research, Vol. 19, No. 5, p 1253-1265, October, 1983. 11 Fig, 2 Tab, 26 Ref.

Descriptors: *Mass transport, *Geologic fractures, *Dispersion, *Stochastic process, Model studies, Groundwater movement, Diffusion, Hydraulic gradient.

A stochastic modeling technique has been developed to investigate mass transport in a network of discrete fractures. The model is based on the repetitive generation of realizations of a fracture network from probability distributions, describing the fracture geometry, and on a solution for mass transport within each network, using a particle-tracking technique. The system consists of two orthogonal fracture sets of finite length, oriented at various angles with respect to the direction of the mean hydraulic gradient. Emphasis is placed on describing the character of dispersion, which develops as a consequence of fracture interconnectivity, and on testing the validity of the conventional diffusion-based model of dispersion in describing transport in fractured media. Results show that mass distributions have a complex form. Marked longitudinal dispersion can develop even a short distance from a source. The distribution of mass in the direction of flow has a consistent negative skew. This pattern of dispersion arises from the limited number of pathways for mass to migrate through the network. Controlling factors in the transport process are the orientation of the fracture sets with respect to the mean hydraulic gradient, the difference in the mean flow velocity in the two fracture sets, and the standard deviation in velocity for fracture set 1. Transport patterns can change greatly as the orientation of the hydraulic gradient changes with respect to the two fracture sets. A conventional diffusion-based model of dispersion cannot characterize transport in these fracture networks. A skewed spatial distribution of mass is observed much more frequently than a Gaussian distribution. When the mean velocities in the two fracture sets are not equal, the form of mass spreading is described by a more general, skewed distribution that accounts for the bias in the probability of mass moving along one fracture set over another. There is a tendency for mass to form a more symmetric distribution as the orientation of the two fracture sets is rotated toward a 45 degree angle with respect to the direction of the mean hydraulic gradient. Furthermore, constant dispersivity values or simple dispersivity functions are not definable because of the sensitivity of transport to the local velocity field in the fracture network. (Author's abstract)
W84-02766

TIME-DEPENDENT LINEARIZED TWO-DIMENSIONAL INFILTRATION AND EVAPORATION FROM NONUNIFORM AND PERIODIC STRIP SOURCES,

Auburn Univ., AL. Dept. of Civil Engineering.
V. Batu.
Water Resources Research, Vol. 19, No. 6, p 1523-1529, December, 1983. 7 Fig, 16 Ref.

Descriptors: *Infiltration, *Evaporation, *Soil surfaces, Mathematical models, Permeability coefficient, Soil water, Matric flux potential, Irrigation systems, Porous media.

Using a linearized partial differential equation describing unsaturated, homogeneous, and isotropic porous media flow, a general two-dimensional time-dependent mathematical model is presented for infiltration and infiltration-evaporation cases from nonuniform and periodic strip sources located at the soil surface. The analysis is based on an exponential relationship between the unsaturated hydraulic conductivity and the soil water pressure head and also assumes a constant value for the derivative of unsaturated hydraulic conductivity with respect to water content. In the mathematical analysis, Laplace transform and Fourier analysis techniques are used simultaneously, and a general equation is obtained in series-integral form for the distribution of matric flux potential. The solution for uniform infiltration from equally spaced strip sources and uniform evaporation from the rest of the strips is presented as a special case of the general model. Another special case is presented for infiltration from equally spaced strip sources. The results of this latter case are compared with Warrick and Lomen (Soil Sci. Soc. Am. J,. 40, 639-643, 1976), and it is observed that the agreement is reasonably good. All results are expressed in integral forms and are calculated by using a numerical integration method. Equations for the horizontal and vertical flux components for the special case are presented. The solutions predict that matric flux potential and flux components as functions of space and time. They are of interest in the design of irrigation systems and may be used also for different purposes in other engineering applications. (Author's abstract)
W84-02854

WATER MOVEMENT INTO SEASONALLY FROZEN SOILS,

Alaska Univ., Fairbanks. Inst. of Water Resources.
D. L. Kane, and J. Stein.
Water Resources Research, Vol. 19, No. 6, p 1547-1557, December, 1983. 11 Fig, 2 Tab, 17 Ref.
OWRT project A-068-ALAS.

Descriptors: *Infiltration, *Snowmelt, *Soil water, *Frozen soils, Pore pressure, Gravitational gradient, Ice, Silt loam, Alaska, Fairbanks.

Depending upon the total (water and ice) soil moisture conditions near the ground surface, a wide range of infiltration rates can exist. This disparity in the infiltration rate results in considerable variation in the amount of snowmelt runoff. The field site for investigating infiltration properties of seasonally frozen soils was located just north of Fairbanks, Alaska. The area selected is on a permafrost-free, south-facing slope. The predominant soil type in this area is Fairbanks silt loam. Double-ring infiltrometers were installed to measure to infiltration properties of the frozen soil. Soil samples were collected to a depth of 1 m, and the gravimetric method was used to determine moisture contents for 5-cm increments. The two main forces responsible for the infiltration rate into seasonally frozen soils are the pore-pressure (matrix) gradient and gravitational gradient. When the infiltration rate at equilibrium exceeds the hydraulic conductivity at saturation, the pore-pressure gradient is greater than zero and is responsible for the additional flow. The pore-pressure gradient is greatest initially and it rapidly approaches zero when the gravitational gradient is dominant. The gravitational gradient is the only gradient that exists when equilibrium conditions prevail. Depending upon the total moisture content prior to infiltration from snowmelt, a range of infiltration rates will be observed for each soil type. Higher infiltration rates will be observed for drier soils and lower infiltration rates for ice-rich soils. Using the equilibrium infiltration rate during the entire melt period should not lead to significant error when predicting runoff and infiltration quantities. Snowmelt events last for several days or even weeks, and the infiltration rate usually approaches equilibrium conditional within an hour, and variations from the equilibrium infiltration infiltration rate only last for short periods of time. (Moore-IVI)
W84-02856

OPTIMIZATION OF PARAMETERS IN A MODEL OF SOIL WATER DRAINAGE,

Commonwealth Scientific and Industrial Research Organization, St. Lucia (Australia). Div. of Tropical Crops and Pastures.
B. H. Wall, and A. J. Miller.
Water Resources Research, Vol. 19, No. 6, p 1565-1572, December, 1983. 2 Fig, 2 Tab, 29 Ref, 1 Append.

Descriptors: *Soil water, *Permeability coefficient, *Drainage, Soil matric potential, Mathematical models, Soil moisture depletion.

A serious obstacle to widespread application of soil water flow theory to small plots is the difficulty of specifying the moisture characteristics psi(theta, z), and conductivity characteristics K(theta, z), in the face of lateral heterogeneity of these properties. A method is presented for the simultaneous determination of effective in situ psi(theta, z) and K(theta, z), given only soil moisture depletion data. The procedure uses a nonlinear least squares fitting routine to find a psi(theta, z) which, with its related K(theta, z), produces calculated fluxes matching those observed. The agreement is an order of magnitude better than that obtained using characteristics determined from laboratory measurements on field samples. (Author's abstract)
W84-02857

MONITORING THE UNFROZEN WATER CONTENT OF SOIL AND SNOW USING TIME DOMAIN REFLECTOMETRY,

Alaska Univ., Fairbanks. Inst. of Water Resources.
J. Stein, and D. L. Kane.
Water Resources Research, Vol. 19, No. 6, p 1573-1584, December, 1983. 12 Fig, 2 Tab, 19 Ref.

Descriptors: *Time domain reflectometry, *Soil water, *Snow, *Snowmelt, Reflectrometry, Infiltration, Snow density.

Time domain reflectometry (TDR) is a technique that can be used to indirectly measure the in situ moisture content of soil. Previously, this method was not used in the field to continuously monitor the liquid water content because of the influence it had on the wetting, drying, freezing and thawing cycles of the soil. The principal objectives of this field investigation were, apply the TDR technique to monitor the unfrozen water content in the soil, utilize this technique to determine snowmelt infiltration into seasonally frozen soils, and explore the feasibility of using the TDR technique to monitor snowmelt percolation in the snowpack. An additional goal of this paper was to explain in a straightforward manner how to use the TDR technique to obtain the liquid water profile in a soil. Various configurations of parallel transmission

lines were installed horizontally at various depths in the soil and also in the snowpack. This technique gave a good delineation of the unfrozen water content with depth in frozen soils. Results looked promising in snow if in situ snow density measurements were taken along with the TDR measurements. (Author's abstract)
W84-02862

SENSITIVITY ANALYSIS OF A LUMPED-PARAMETER MODEL FOR INFILTRATION,
Helsinki Univ. of Technology, Espoo (Finland). Systems Theory Lab.
K. Pingoud.
Journal of Hydrology, Vol. 67, No. 1-4, p 97-113, 1984. 4 Fig, 15 Ref, 2 Append.

Descriptors: *Infiltration, *Sensitivity analysis, Mathematical models, Rainfall, Soil saturation.

Sensitivity analysis provides a useful tool that can be conveniently applied to study the properties of the lumped-parameter model for infiltration. The sensitivities of the momentary infiltration rate and cumulative infiltration are clear measures for the behavior of the model. The scaled representation of the model used in the computations has the advantage that the numerical results obtained can be directly applied to different combinations of the parameter values in the original model. One question is the sensitivity to the initial value of the soil saturation. Only the model behavior during constant rainfalls is considered, implying that the soil is in a wetting phase all the time. One aim of the analysis is to study qualitatively the properties of the model structure. Reasonable values for the optimal parameters in a practical application can be estimated on the basis of the sensitivity functions. (Moore-IVI)
W84-02888

SOIL-WATER RESIDENCE TIME AND SOLUTE UPTAKE,
Sheffield Univ. (England). Dept. of Geography.
K. R. J. Smettem.
Journal of Hydrology, Vol. 67, No. 1-4, p 235-248, 1984. 4 Fig, 3 Tab, 29 Ref.

Descriptors: *Soil moisture retention, *Solutes, Soil water, Soil chemistry, Solute transport, Soil properties.

There is a need to evaluate whether analytical solutions based on the concept of physical nonequilibrium are capable of describing solute transfer in undisturbed field soils. This study used undisturbed soil cores in order to provide data against which a suitable analytical model could be tested. Measured breakthrough curves were well described by an analytical solution incorporating mobile and stagnant regions with sideward exchange. Resulting transport parameters were dependent upon the input flux rate, reflecting a pattern of increasing breakthrough curve asymmetry with increasing flux. This was attributed to the combined influences of pedal by-passing and increasing non-equilibrium for diffusion-controlled solute transfer between the mobile and stagnant regions. The stagnant region model is adequate for describing solute transport in a well-structured undisturbed field soil. (Murphy-IVI)
W84-02895

THE MOVEMENT OF WATER THROUGH CORES OF A DRY (CRACKED) CLAY-LOAM GRASSLAND TOPSOIL,
Oxford Univ. (England). Dept. of Agricultural Science.
W. R. Kneale, and R. E. White.
Journal of Hydrology, Vol. 67, No. 1-4, p 361-365, 1984. 2 Fig, 1 Tab, 5 Ref.

Descriptors: *Soil water, *Rainfall, *Grasslands, Clays, Topsoil, Permeability, Loam, Infiltration, Soil moisture deficit, England.

Soil cores were taken from the Ah horizon of a grassland field in the Wytham catchment near Oxford, England. The soil was dry and cracks were well developed. The initial volumetric moisture contents of the cores were in the range of 0.26-0.30 cu m/cu m, corresponding approximately to wilting point compared to total porosities of 0.63-0.66 cu m/cu m. At the lowest application rate, 2.2 mm/hr, a total of 17.6 mm of water was applied without producing any flow of water from the base of the core. Bypassing did not occur and the infiltration rate into the surface peds equalled the application rate. At the other rates of application, 3.6, 11.9, and 21.2 mm/hr, outflow from the cores was first noted after the application of 2.7, 3.2, and 3.4 mm of water, respectively. Once outflow started it rapidly achieved a steady state at a rate lower than the application rate. It was estimated that 10-20% of rainfall bypassed the top 0.09 m of this grassland soil during periods of summer soil-moisture deficit. (Baker-IVI)
W84-02902

NITROGEN AND PHOSPHORUS FLUXES FROM A FLOODED ORGANIC SOIL,
Agricultural Research and Education Center, Sanford, FL.
For primary bibliographic entry see Field 2K.
W84-02908

INTERFACING SOIL MOISTURE GYPSUM BLOCKS WITH A MODERN DATA-LOGGING SYSTEM USING A SIMPLE, LOW-COST, DC METHOD,
Institute of Hydrology, Wallingford (England).
For primary bibliographic entry see Field 7B.
W84-02909

2H. Lakes

SEASONAL CHANGE OF DENSITY STRATIFIED LAYER IN KATSURAZAWA RESERVOIR,
Hokkaido Univ., Sapporo (Japan). Inst. of Low Temperature Science.
M. Ohtani, and I. Yakuwa.
Japanese Journal of Limnolology, Vol. 44, No. 3, p 206-214, July, 1983. 76 Fig, 2 Tab.

Descriptors: *Reservoirs, *Density stratification, *Seasonal variation, *Katsurazawa Reservoir, Japan, Water temperature, Suspended solids, Thermoclines, Snowmelt.

The seasonal variation of water temperature and suspended solid concentrations (SS) were measured in Katsurazawa Reservoir in a period from May, 1978 to April, 1979. Measurements were carried out at a station 50-100 m from the damsite. In early spring the reservoir was filled with water of low temperature and high SS which was caused by the melting snow. The inflow water formed the transitional SS layer at the same depth as thermocline in spring and early summer. In the circulation period after summer, both the thermocline and the SS transitional layer descended toward the bottom. In November and December, the latter remained at a depth of about 30 m after the former had disappeared, showing that the thickness of the surface mixing layer could not be adequately estimated only by the apparent thermocline. Concentration of SS increases exponentially with depth in each of the surface and the bottom layers. The vertical gradients change under the influence of seasonal climate condition. In the heating period, water density of the surface layer is much lower than in the bottom layer, and so the density stratification is stable. On the other hand, the gradient of vertical distribution of water density is small and the stratification is unstable in the cooling period. (Author's abstract)
W84-02481

THE IMPORTANCE OF FRACTIONAL LIGHT ABSORPTION BY PHOTOSYNTHETIC PIGMENTS FOR PHYTOPLANKTON PRODUCTIVITY IN LAKE CONSTANCE,
Konstanz Univ. (Germany, F.R.). Limnological Inst.
M. M. Tilzer.
Limnology and Oceanography, Vol. 28, No. 5, p 833-846, September, 1983. 5 Fig, 1 Tab, 35 Ref. Deutsche Forschungsgemeinschaft grants Ti 115/3 and Ti 115/10-2.

Descriptors: *Phytoplankton, *Light absorption, *Productivity, *Lake Constance, *Pigments, *Photosynthesis, Biomass, Light attenuation, Light extinction, Pheopigments, Solar radiation, Chlorophyll a, Lakes.

The role of light interception by photosynthetic pigments on the productivity of phytoplankton was studied year-round in mesotrophic Lake Constance. The phytoplankton showed wide seasonal fluctuations in both biomass (Chl a) and photosynthesis. Linear regression was used to determine pigment-specific light attenuation and nonalgal light extinction. Fractional light absorption by photosynthetic pigments ranged from 4 to 70%. Pheopigments comprised 27.4 + or - 8.2% of total pigments. Since pheopigments do not transfer energy to the photosystems, their light absorption must be added to the background light attenuation by nonphotosynthetic material. If pheopigments are considered, estimates of fractional light absorption decrease accordingly. A plot of integral photosynthesis vs. maximum photosynthesis at the depth of the optimum light intensity gives a saturation curve, due to increasing fractional light absorbance by photosynthetic pigments at rising concentrations of biomass. Integral photosynthesis would reach a theoretical upper limit is all light were absorbed by active photosynthetic pigments. Since pheopigment concentrations usually rise with active Chl a, background light attenuation increases also, leading to diminished productivity per unit of lake surface area. (Author's abstract)
W84-02483

CAROTENOID ENHANCEMENT AND ITS ROLE IN MAINTAINING BLUE-GREEN ALGAL (MICROCYSTIS AERUGINOSA) SURFACE BLOOMS,
North Carolina Univ. at Morehead City. Inst. of Marine Sciences.
For primary bibliographic entry see Field 5C.
W84-02484

THE PRODUCTION OF BACTERIA ATTACHED TO PARTICLES SUSPENDED IN A FRESHWATER POND,
Harvard Univ., Cambridge, MA. Div. of Applied Sciences.
D. Kirchman.
Limnology and Oceanography, Vol. 28, No. 5, p 858-872, September, 1983. 6 Fig, 3 Tab, 56 Ref. NSF grant DEB-79-20909 and NOAA Sea Grant NA81AAA-D-00085.

Descriptors: *Suspended solids, *Bacterial productivity, Ponds, Biomass, Seasonal variation, Detritus, Carbon, Ponds, Metabolism, Glucose, Glutamate, Acetate, Thymidine.

The biomass and activity of particle-bound bacteria in a small freshwater pond were examined during 2 years. The percentage of total bacteria attached to particles was highest (3%) in the months of July through October. During this period the number of bacteria per particle and the number of particles per milliliter were also relatively high. An average attached bacterium was larger than an unattached bacterium in July and August but not in February and May. Cell volumes of both populations were larger in summer than in winter. The uptake of three C14-labeled compounds and the incorporation of (H3) thymidine into marcromolecules were also examined. Although there was no seasonal pattern in the percentage of activity contributed by the >3.0-micro m fraction, this fraction took up relatively more glucose (21% of total uptake) than glutamate (12%) or acetate (6.8%). Thymidine incorporation by the large bacteria was relatively low (2.8%). The production of bacteria attached to particles was estimated from rates of thymidine incorporation and used to estimate the remineralization rate of detrital carbon by particle-bound bacteria. Detrital carbon in Ice House Pond was apparently not

remineralized substantially by particle-bound bacteria. (Author's abstract)
W84-02485

THE CAUSES AND CONSEQUENCES OF SEX-SPECIFIC MORTALITY IN A FRESHWATER COPEPOD,
Rhode Island Univ., Kingston. Dept. of Zoology.
N. G. Hairston, Jr., W. E. Walton, and K. T. Li.
Limnology and Oceanography, Vol. 28, No. 5, p 935-947, September, 1983. 3 Fig, 4 Tab, 31 Ref. NSF grant DEB-8010678.

Descriptors: *Mortality, *Copepods, *Reproduction, *Sex ratio, Sunfish, Predation, Population dynamics, Bullhead Pond, Little Bullhead Pond, Rhode Island.

Skewed adult copepod sex ratios were studied in Bullhead and Little Bullhead Ponds and two temporary ponds in Rhode Island in an attempt to understand the ecological causes and evolutionary consequences of this life-history phenomenon. In ponds containing populations of zooplanktivorous sunfish, female copepods suffered higher mortality rates than males, while in ponds lacking these predators, male and female mortality rates were similar. Field and laboratory experiments showed that females, especially those carrying eggs, were more visible than males and that added visibility accounted for higher predation by fish on these individuals. The cost of carrying eggs was calculated in terms of the decreased population growth rate it produces, and then the magnitude of egg mortality necessary to select for the egg-carrying strategy was estimated. Eggs not carried would have to suffer at least 58% mortality for egg carrying to evolve in the presence of selective fish predation. The response of the copepods to these strong selective pressures lies in a third direction, the production of diapausing eggs. In Bullhead and Little Bullhead Ponds, the copepods begin producing diapausing eggs in late March and early April, just before fish predation becomes intense. (Moore-IVI)
W84-02486

THE EFFECT OF FOOD QUALITY ON FEEDING AND RESPIRATION BY DAPHNIA AND DIAPTOMUS,
Lawrence Univ., Appleton, WI. Dept. of Biology.
S. Richman, and S. I. Dodson.
Limnology and Oceanography, Vol. 28, No. 5, p 948-956, September, 1983. 5 Fig, 1 Tab, 31 Ref.

Descriptors: *Food habits, *Daphnia, *Diaptomus, *Respiration, Cyanophyta, Competition, Eutrophic lakes, Mesotrophic lakes, Oligotrophic lakes, Mathematical models.

Filtering, ingestion, and respiration rates for Daphnia pulex and Diaptomus siciloides were measured in southern Green Bay water mixed with algal cultures to produce varying proportions in blue-green algae. These measurements along with observations of Daphnia mouthpart responses to these foods were used to assess the relative competitive potential of Daphnia and calanoid copepods in lakes of varying trophy. Ratios of filtering and ingestion rate to respiration rate were used as a measure of energy input per unit of energy expended. Passive filtering and subsequent rejection of inedible algae by Daphnia result in higher ratios than those shown by Diaptomus in high quality foods, suggesting a competitive advantage in oligotrophic or mesotrophic lakes. Diaptomus selective feeding, on the other hand, results in higher ratios in the low quality food characteristic of eutrophic conditions. These results and data from the literature are used to propose a two-dimensional niche model to demonstrate the interaction between food quality and abundance on the competitive interaction between calanoid copepods and Daphnia-like cladocerans. (Author's abstract)
W84-02487

FREEZE-OUT OF SALTS IN HARD-WATER LAKES,
Iowa State Univ., Ames. Dept. of Animal Ecology.
D. E. Canfield, Jr., R. W. Bachmann, and M. V. Hoyer.
Limnology and Oceanography, Vol. 28, No. 5, p 970-977, September, 1983. 3 Fig, 4 Tab, 15 Ref. OWRT project A-063-IA.

Descriptors: *Alkalinity, *Hardness, *Freezing, *Melting, Hydrogen ion concentration, Ice cover, Dilution, Salts, Clear Lake, Iowa.

A 15-year series of daily measurements of pH and total alkalinity recorded at the water intake of a municipal water-treatment plant on Clear Lake, Iowa, demonstrated that rapid chemical changes occur annually as the ice cover melts. Additional measurements of total and calcium hardness on this and three other eutrophic, hard-water lakes showed that total and calcium hardness concentrations declined rapidly as the main ice mass was destroyed. The changes in total alkalinity occur within 4-5 days of ice-out. In some years alkalinity in Clear Lake decreases as much as 40 mg/l as CaCO3 in 1 day. This decline was not caused by chemical or biological precipitation of carbonates, but by a dilution effect of melting ice. The rate of reduction is related to the removal rate of the ice cover. The magnitude of the declines could be predicted from measurements of hardness under the ice, lake volume, and volume of ice. The data strongly support the hypothesis that freeze-out of salts during ice formation is responsible for most of the increase in hardness and alkalinity in Iowa lakes and that the subsequent declines in hardness and alkalinity are primarily due to the dilution of lake water by relatively pure meltwater. (Moore-IVI)
W84-02488

COEXISTENCE AND INTERFERENCE IN TWO SUBMERSED FRESHWATER PERENNIAL PLANTS,
Notre Dame Univ., IN. Dept. of Biology.
N. J. McCreary, S. R. Carpenter, and J. E. Chaney.
Oecologia, Vol. 59, No. 2-3, p 393-396, 1983. 3 Fig, 1 Tab, 25 Ref.

Descriptors: *Submerged plants, *Eleocharis, *Juncus, Growth, Competition, Interactions, Aquatic environment.

Interactions between two codominant submersed freshwater perennial plants, Eleocharis acicularis (L.) R. and S. and Juncus pelocarpus forma submersus Fassett, were studied in a softwater lake. Analysis of segregation indicated a nonrandom arrangement of individual rosettes of each species with respect to rosettes of the other species. Factors influencing growth of the species were examined using de Wit replacement series replicated four times at five ratios, under three environmental treatments: sphagnum peat, double field density, and shading and a control. Plants grown in pure culture showed no significant difference in yield between the two species. When plants were grown in mixture, there were significant differences between species. Yields of both species were significantly different among environmental treatments. A significant effect of Eleocharis : Juncus ratio in the double density treatment resulted from interference among conspecific neighbors. Relative Yield Totals ranged from 0.84 to 1.0 for all four treatments, and ratios diagrams indicate stable coexistence through the growing season under all four environmental regimes. Interspecific interference was less important than environmental factors and intraspecific interference in determining growth in these experiments. Eleocharis and Juncus are nonrandomly intermingled, and can coexist under a variety of environmental manipulations. This outcome is consistent with their reported distributions in nature. The mechanism that permits this stable coexistence awaits explanation. (Author's abstract)
W84-02492

GROWTH AND PRODUCTION OF SYMPATRIC BROOK AND RAINBOW TROUT IN AN APPALACHIAN STREAM,
Tennessee Univ., Knoxville. Dept. of Forestry, Wildlife and Fisheries.
W. E. Whitworth, and R. J. Strange.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 469-475, July, 1983. 1 Fig, 2 Tab, 31 Ref.

Descriptors: *Trout, *Growth, Biomass, Mortality, Seasonal variation, Fish behavior, Stream fisheries.

A small, second-order stream in the southern Appalachians was sampled every 2 months from September 1978 to October 1979. The 1.5-km study segment was divided into 50, 30-m sections grouped into three areas: a downstream area with only rainbow trout Salmo gairdneri; a middle, mixed-trout area; an upstream area with predominantly brook trout Salvelinus fontinalis. Although a few fish of both species exhibited substantial movements, the majority of fish moved less than 30 m either upstream or downstream. Growth rates of both species were approximately equal until the spring of their second year, when rainbow trout outgrew brook trout and thereafter maintained a size-at-age advantage. Rainbow trout, particularly the 1978 cohort, dominated trout production in the stream. Even in the brook trout area, where the density of 1978 cohort brook trout was twice that of 1978 cohort rainbow trout, rainbow trout outproduced brook trout by 1.20 g/sq m to 1.14 g/sq m. Declining mean biomass of older fish of both species indicates high winter mortality. This, accompanied by slow growth of older fish, resulted in very few fish of either species entering the legal fishery. (Author's abstract)
W84-02522

FOOD PARTITIONING BETWEEN YOUNG OF THE YEAR OF TWO SYMPATRIC TUI CHUB MORPHS,
Colorado Cooperative Fishery Research Unit, Fort Collins.
D. L. Galat, and N. Vucinich.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 486-496, July, 1983. 5 Fig, 3 Tab, 40 Ref.

Descriptors: *Chub, *Fish food organisms, Fish management, Zooplankton, Invertebrates, Chironomids, Morphology, Pyramid Lake, Nevada.

The hypothesis that young of the year of two sympatric morphs of tui chub Gila bicolor were trophically indistinguishable was tested in Pyramid Lake, Nevada. Based on gill-raker counts, young-of-the-year tui chubs longer than 25 mm fork length could be separated into distinct morphs, G. b. obesa (fewer gill rakers) and G. b. pectinifer. Undesignated juveniles shorter than 26 mm, collected from depths 1 m and less, ate primarily zooplankton plus small quantities of macroinvertebrates. Among G. b. obesa, consumption of macroinvertebrates, principally chironomids, rose to 41% for fish 26-50 mm long and to 62% for fish 51-75 mm long. Among G. b. pectinifer, diets of fish 26-50 mm and 51-75 mm long contained 93 and 100% zooplankton, respectively. As young of the two morphs grew larger, their gill-raker distributions became nonoverlapping. Divergence in food selection accompanied the shift in numbers of gill rakers. The results suggest that sympatric morphological variants of polytypic fishes like tui chub should be treated as functionally distinct species for fishery-management considerations. (Author's abstract)
W84-02524

FEEDING ECOLOGY OF COEXISTING LARVAE OF AMERICAN SHAD AND BLUEBACK HERRING IN THE CONNECTICUT RIVER,
Connecticut Dept. of Environmental Protection, Hartford.
V. A. Crecco, and M. M. Blake.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 498-507, July, 1983. 2 Fig, 3 Tab, 58 Ref.

Descriptors: *Shad, *Herring, *Larvae, *Fish food organisms, *Connecticut River, Zooplankton, Competition, Predation.

Food-habit, niche-breadth, and diet-overlap analyses were conducted for larvae of American shad Alosa sapidissima and blueback herring Alosa aestivalis collected from the Connecticut River from June 3 to July 15, 1981. River zooplankton densities (number/cu m) were used to assess the influences of prey availability on niche-breadth and diet-overlap indices for the species. Niche-breadth values were consistently higher for blueback herring than for American shad larvae. American shad fed mostly on the less-abundant crustaceans and immature insects, whereas blueback herring larvae usually utilized the numerically dominant rotifers. The cladoceran Bosmina sp. was utilized extensively by American shad of all sizes and by 13-16-mm blueback herring larvae, and was the only prey for which interspecific competition between the larval predators might occur. The mean mouth gape of American shad larvae was always larger than that of blueback herring larvae at a given length, and American shad larvae of all sizes generally selected the larger cyclopoid copepodites and chronomid larvae. The diet-overlap indices varied over time, but were generally higher among length groups within species than between species, suggesting that intraspecific competition for food may be more severe than interspecific competition. (Author's abstract)
W84-02525

PISCIVOROUS FEEDING BEHAVIOUR OF LARGEMOUTH BASS: AN EXPERIMENTAL ANAYLSIS,
Kansas Univ., Lawrence. Dept. of Systematics and Ecology.
G. L. Howick, and W. J. O'Brien.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 508-516, July, 1983. 5 Fig, 4 Tab, 42 Ref.

Descriptors: *Bass, *Fish behavior, *Fish food, *Bluegill, Predation, Light intensity.

Largemouth bass Micropterus salmoides are the dominant top carnivores of many North American lakes and reservoirs and are very popular sport fish, but the actual behavioral mechanisms of their feeding are still poorly known. In laboratory experiments predation was broken into its component parts: location, pursuit, attach, and handling of prey. The distance at which largemouth bass can locate forage fish increases with prey size, with prey motion (when prey are small), and with light intensity. In the pursuit phase of the predation cycle, largemouth bass are more likely to choose prey with large apparent size, closer proximity, or greater motion. When bluegills Lepomis macrochirus were the experimental prey, the number of attempted attacks by largemouth bass before the prey was ingested increased with bluegill size, within broad limits. At high light intensities bluegills can locate modest-size largemouth bass (29 cm total length) long before the predators locate them, but at low light intensities, the advantage is reversed. (Author's abstract)
W84-02526

DISTRIBUTION AND GROWTH OF LARVAL RAINBOW SMELT IN EASTERN LAKE MICHIGAN, 1978-1981,
Michigan Univ., Ann Arbor. Great Lakes Research Div.
H. T. Tin, and D. J. Jude.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 517-524, July, 1983. 3 Fig, 28 Ref.

Descriptors: *Smelt, *Larvae, *Distribution, *Growth, *Lake Michigan, Hatching, Water temperature, Seasonal variation, Water depth, Exotic fish.

Rainbow smelt is an introduced marine exotic with the potential for disrupting the Lake Michigan ecosystem. Distribution and growth of rainbow smelt Osmerus mordax larvae are described from samples collected in eastern Lake Michigan during 1978-1981 with plankton nets and benthic sleds deployed in water 1-15 m deep. This work was part of the investigations of fish populations in the vicinity of the J. H. Campbell electricity-generating plant located near Port Sheldon, Michigan. Rainbow smelt larvae less than 25.5 mm total length were caught from May to early August, whereas young of the year 25.5 mm and large occurred from July to September. Newly hatched larvae were found mostly during May; however, some hatching occurred in late June or early July, apparently due to slower incubation of eggs in deep cooler water. After hatching, rainbow smelt larvae were distributed in shallow water for a short period; from June to early August larvae were widely dispersed. Larvae concentrated inshore in late August. They generally were found at a few random depth strata from May to early August. In late August concentrated near bottom. Larval rainbow smelt were most common at water temperatures of 10 to 16 C. Rainbow smelt averaged from 5.3 to 6.1 mm in May; they grew to a mean length of 15.7 mm after 1 month and to 36.5-41.1 mm after 3 months. (Moore-IVI)
W84-02527

EFFECTS OF COMPLETE REDD DEWATERING ON SALMONID EGG-HATCHING SUCCESS AND DEVELOPMENT OF JUVENILES,
Idaho Cooperative Fishery Research Unit, Moscow.
For primary bibliographic entry see Field 6G.
W84-02528

RELATIVE SUSCEPTIBILITY OF FOUR STRAINS OF SUMMER STEELHEAD TO INFECTION BY CERATOMYXA SHASTA,
Oregon Dept. of Fish and Wildlife, Corvallis.
D. V. Buchanan, J. E. Sanders, J. L. Zinn, and J. L. Fryer.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 541-543, July, 1983. 1 Tab, 5 Ref.

Descriptors: *Salmon, *Ceratomyxa, *Columbia River, *Fish pathology, Parasites, Infection, Fish stocking.

All the summer steelheads Salmo gairdneri from the Siletz, an Oregon coastal river in which Ceratomyxa shasta does not occur, died when they were exposed to waters containing the infectious stage of C. shasta. In contrast, three strains of summer steelhead from tributaries of the Columbia River where C. shasta is endemic were resistant to ceratomyxosis. Salmonids from populations living in waters free of the infective stage of C. shasta should not be stocked in waters containing the pathogen. Columbia River summer steelheads are exposed to the infectious stage of C. shasta both as smolts emigrating in the spring and as adults ascending the Columbia River during the summer. The historical exposure has resulted in resistance to C. shasta probably through the process of natural selection. (Moore-IVI)
W84-02529

EXPERIMENTAL TESTS OF OPTIMAL HABITAT USE IN FISH: THE ROLE OF RELATIVE HABITAT PROFITABILITY,
Michigan State Univ., Hickory Corners. W.K. Kellogg Biological Station.
E. E. Werner, G. G. Mittelbach, D. J. Hall, and J. F. Gilliam.
Ecology, Vol. 64, No. 6, p 1525-1539, 1983. 9 Fig, 3 Tab, 30 Ref, 1 Append. NSF grants DEB-7824271, DEB-8119258, and DEB-8104697.

Descriptors: *Bluegills, *Fish food, *Aquatic habitats, *Model studies, Predation, Daphnia, Midges, Prediction, Fish behavior, Habitats, Feeding.

Animals generally exhibit considerable selection in the foods they consume and the habitats they use, and these choices are considered to be important to their relative fitness. Optimal foraging theory and laboratory estimates of foraging costs were used to predict the choice of foods and use of habitats by fish in the field. These predictions are tested with the bluegill sunfish (Lepomis macrochirus) foraging in three habitats (open water, sediments, and vegetation) in a pond. Relations describing prey encounter rates in each habitat as a function of prey size, prey density and fish size were derived from laboratory experiments. These relations were used to estimate prey encounter rates based on weekly prey samples in each habitat of the pond. The optimal diet and profitability (net energy return) were determined for each habitat through time. Predictions of optimal diet exhibited good qualitative correspondence to the actual diet of the fish in the open water and vegetation, although a slightly narrower diet consistently predicted than the fish were choosing. The model correctly predicted the magnitude of the change in size selection on Daphnia pulex with fish size and with decline in prey density. Predictions of optimal diet in the sediments were considerably in error apparently due to a tendency for late-instar midges to burrow deep in the sediments, thereby becoming unavailable to the fish. In this case habitat profitabilities were computed simply on the basis of the actual observed diet. Predictions of optimal habitat use showed striking correspondence to the actual habitat use of the fish; the bluegills switched from feeding in the open water column to feeding from the sediments within a few days of the predictions. The actual habitat use pattern differs dramatically from a null model of random habitat use. This approach may be useful in studying intra- and interspecific exploitative interactions. (Moore-IVI)
W84-02542

PREDATOR-PREY INTERACTIONS AND BREEDING-POND USE OF TEMPORARY-POND SPECIES IN A DESERT ANURAN COMMUNITY,
New Mexico Univ., Albuquerque. Dept. of Biology.
B. D. Woodward.
Ecology, Vol. 64, No. 6, p 1549-1555, 1983. 1 Fig, 4 Tab, 32 Ref.

Descriptors: *Tadpoles, *Temporary ponds, *Predation, *Ponds, Chihuahuan Desert, New Mexico, Anura, Reproduction, Behavior.

Several anuran species in central New Mexico have access to both permanent and temporary ponds yet typically use only one or the other pond type. Six anuran species were studied in the Chihuahuan Desert in Socorro County, central New Mexico. From 1 August to 3 September 1978, 16 temporary and 17 permanent ponds were sampled during midday to determine relative predator densities. Predators found only at night were very uncommon and were estimated by counting tracks around ponds. More individual terrestrial predators, more terrestrial predator species, and more individual aquatic predators per cubic meter exist in permanent than in temporary ponds, suggesting that predators may prevent temporary-pond species from using permanent ponds. Eight predator species consumed more temporary- than permanent- pond tadpoles in 17 of 20 pairwise choice experiments. Temporary-pond tadpoles, were almost continually in motion, while permanent-pond tadpoles were almost always stationary. This differential movement may account for the vulnerability of temporary-pond tadpoles to predation. The nonrandom distribution of predators in this tadpole community and the inability of some tadpoles to avoid predation apparently restricts some anurans to temporary ponds. (Moore-IVI)
W84-02543

SPATIAL AND TEMPORAL DISTRIBUTION OF BENTHIC DIATOMS IN NORTHERN LAKE MICHIGAN,
Minnesota Univ., Minneapolis. Limnological Research Center.
J. C. Kingston, R. L. Lowe, E. F. Stoermer, and T. B. Ladewski.
Ecology, Vol. 64, No. 6, p 1566-1580, 1983. 11 Fig, 2 Tab, 64 Ref. NSF grant OCE 77-21854.

Descriptors: *Diatoms, *Spatial distribution, *Temporal distribution, *Lake Michigan, *Benthos, Plankton, Overwintering, Species diversity, Seasonal variation.

Benthic diatom communities were sampled from natural substrates along a depth transect in northern Lake Michigan to examine spatial and seasonal distribution patterns and define assemblages of associated taxa. Information-theory diversity, evenness, and richness were significantly higher in deep assemblages than in shallow assemblages, with the boundary falling between 5 and 10 m in winter and fall, 10 and 20 m in spring, and 20 and 31 m in summer. Planktonic taxa are abundant on benthic substrates in the deep zone, primarily as dead fallout. In shallow water, large numbers of living planktonic taxa overwinter beneath the ice on benthic substrates. Cluster analysis of samples was used to identify and define diatom assemblages from deep, mid-depth, and shallow water. The deepwater assemblage contains motile and nonmotile benthic species that have been reported from alpine and boreal oligotrophic lakes. The mid-depth assemblage is rich in epipsammic taxa. The shallow-water assemblages contain cosmopolitan taxa that are collected often in nearshore plankton samples. These shallow assemblages do not persist throughout the year as do the deep and mid-depth assemblages. Cluster analysis of taxa provides further definition of species associations and the degree of correlation among species. Correlations among benthic taxa are strengthened when planktonic taxa are removed from the analysis, indicating that plankton fallout represents an addition of information which is poorly related to distribution of the benthic species. The most stable and diverse community is found at the deepest sampling depths where environmental conditions are most stable, the mid-depth community exists in fluctuating but predictable conditions, and the shallow assemblages occur in the zone of maximum physical fluctuation or natural stress. Substrate types are correlated with the species assemblages, but the high diversity of substrate types in shallow water does not support the most diverse assemblage. The discrete species assemblages seen in an oligotrophic area of this large dimictic lake apparently respond sensitively to temporally and spatially dynamic environmental parameters. (Author's abstract)
W84-02544

AUTOTROPHIC PROCESSES IN MEROMICTIC BIG SODA LAKE, NEVADA,
Geological Survey, Menlo Park, CA.
J. E. Cloern, B. E. Cole, and R. S. Oremland.
Limnology and Oceanography, Vol. 28, No. 6, p 1049-1061, November, 1983. 4 Fig, 3 Tab, 46 Ref.

Descriptors: *Autotrophic processes, *Big Soda Lake, *Nevada, *Photosynthesis, *Chemoautotrophy, *Productivity, Phytoplankton, Purple sulfur bacteria, Meromictic lakes, Saline lakes, Seasonal variation, Thermal stratification, Bacteria.

Daily rates of oxygenic photosynthesis (OP) by phytoplankton, anoxygenic photosynthesis (AP) by purple sulfur bacteria, and chemoautotrophic productivity (CP = dark CO2 assimilation) were measured once each season in saline, meromictic Big Soda Lake. Total daily productivity and the relative importance of each autotrophic process varied with seasonal changes in vertical mixing, light availability, and the biomass of phototrophs. Daily productivity was highest (2,830 mg C/sq m) and was dominated by OP in winter when the mixolimnion was isothermal, the biomass of phytoplankton was high, and the biomass of purple sulfur bacteria was low. During the summer-fall period of thermal stratification, phytoplankton biomass decreased, a plate of purple sulfur bacteria formed below the oxycline, and the daily rates of dark CO2 assimilation (CP = 390-680 mg C/sq m) exceeded phototrophic productivity (OP + AP = 200-370 mg C/sq m). Total annual productivity was about 500 g C/sq m, of which 60% was produced by phytoplankton (mostly in winter), 30% by chemoautotrophs (nitrifying and sulfuroxidizing bacteria), and only 10% by photosynthetic bacteria. (Author's abstract)
W84-02545

CARBOXYLATING ENZYME ACTIVITY AND PHOTOSYNTHETIC END PRODUCTS OF PHYTOPLANKTON IN THE SHALLOW AND DEEP CHLOROPHYLL LAYERS OF CASTLE LAKE,
California Univ., Davis. Div. of Environmental Studies.
J. C. Priscu, and C. R. Goldman.
Limnology and Oceanography, Vol. 28, No. 6, p 1168-1181, November, 1983. 4 Fig, 2 Tab, 49 Ref. NSF grant DEB80-19918 and DEB76-19524.

Descriptors: *Phytoplankton, *Photosynthesis, *Castle Lake, *California, Enzyme activity, Carbon metabolism, Water temperature, Light, Nitrogen, Algae.

The patterns of carbon assimilation of the Castle Lake (California) phytoplankton were measured under various environmental conditions. The flow of carbon into polysaccharides and lipids plus low molecular weight metabolites was generally highest at low temperatures and low light (i.e. under-ice and deep-water populations). Enrichment with nitrogen to nitrogen-deficient algae did not significantly alter the patterns of carbon assimilation during time-series experiments. However, the relative rates of polysaccharide and protein synthesis were increased when the entire epilimnion of the lake was fertilized with nitrogen. On the average about 15% more carbon could potentially be fixed by the anaplerotic enzyme phosphoenolpyruvate carboxylase (PEPCase) than the Calvin Cycle enzyme ribulose-1,5-biphosphate carboxylase (RuBPCase). The parameter, RuBPCase : PEPCase/photon saturated in vivo photosynthesis (Pmax), was consistently > 1.0 liter/h/microgram C and showed significant differences between the 3-m and 20-m algal populations, indicating that they may be physiologically distinct with respect to carbon metabolism. The proportion of C14 incorporated into protein increased as the ratio of RuBPCase to PEPCase increased. The converse was true for the relative sythesis of lipid + low molecular weight (LMW) compounds while the proportion of C14 incorporated into polysaccharide varied little with RuBPCase: PEPCase. These findings and others from the literature do not corroborate existing simple biochemical models for this relationship, implying that other carboxylating enzymes may be important in the carbon metabolism of certain algae. (Author's abstract)
W84-02546

BIOCHEMICAL CONSTITUENTS OF PARTICULATE MATTER IN A MESOTROPHIC IRRIGATION POND,
National Inst. for Environmental Studies, Tsukuba (Japan).
A. Otsuki, T. Miyoshi, T. Unno, and H. Seki.
Archiv fur Hydrobiolgie, Vol. 98, No. 1, p 1-14, September, 1983. 5 Fig, 4 Tab, 17 Ref.

Descriptors: *Particulate matter, *Irrigation ponds, *Organic compounds, Amino acids, Fatty acids, Carbohydrates, Mesotrophic lakes, Seasonal variation, Organic matter, Shin-ike Pond, Japan.

Particulate organic matter was sampled in Shin-ike Pond, a representative mesotrophic freshwater pond. The concentrations of particulate organic carbon, particulate amino acids, and particulate fatty acids showed obvious seasonal fluctuations. The concentration started to increase at the beginning of spring up to a moderate level, and was maintained during the spring in a steady state oscillation. The levels further increased drastically at the start of summer and reached maximum levels in August. Concentrations fell rapidly to a moderate level in mid autumn. Levels of organic carbon, amino acids and carbohydrates decreased gradually during winter and reached minimum for the year at the end of winter. The concentration of particulate fatty acids showed a steady-state oscillation during autumn as during spring, and began to decrease at the beginning of winter. Amino acids were the major group, composed chiefly of glutamic acid, aspartic acid, leucine, alanine, glycine, threonine, serine, valine, lysine, phenylalanine, proline, arginine, isoleucine, tyrosine, histidine, and methionine. (Baker-IVI)
W84-02547

POPULATION DYNAMICS OF CAULOBACTERS IN A MESOTROPHIC IRRIGATION POND,
Tsukuba Univ., Ibaraki (Japan). Inst. of Biological Sciences.
H. Ezura, and H. Seki.
Archiv fur Hydrobiolgie, Vol. 98, No. 1, p 15-38, September, 1983. 14 Fig, 20 Ref.

Descriptors: *Population dynamics, *Irrigation ponds, *Caulobacter, Bacteria, Shin-ike Pond, Japan, Seasonal variations, Water temperature, Temperature effects, Mesotrophic lakes, Nitrates, Ammonia, Phosphates, Irrigation water.

Population dynamics of caulobacters were studied in Shin-ike Pond, which is a typical freshwater irrigation pond in Japan. The water in the pond should be categorized as mesotrophic. Heterotrophic bacteria belonging to the genera Caulobacter and Asticcacaulis were a component of the bacterioplankton community. These caulobacters appeared as bacterial pulses in the pond during all seasons of the year. The duration of each pulse was as long as three months in autumn and as short as one month in winter. A pulse of the stalk formation stage of caulobacters was observed in the pond as leading to a following pulse of community growth with a certain time lag. This time lag was shorter in winter and longer in summer. The longer time lag during summer was due partly to the influence of the phytoplankton bloom. Another reason for this longer time lag may be due to active zooplankton grazing of stalked caulobacters during summer when planktonic crustaceans are abundant. The population dyanmics are controlled by organic nutrients dissolved in the pond as the limiting factor. This was clearly shown by the dissolved organic carbon growth relationship expressed as a highly significant regression curve. Water temperature was regarded as a non-limiting factor but had a profound effect on the community growth of caulobacters by modifying biological processes. (Baker-IVI)
W84-02548

THE GRAM-STAIN CHARACTERISTICS OF THE BACTERIAL COMMUNITY AS A FUNCTION OF THE DYNAMICS OF ORGANIC DEBRIS IN A MESOTROPHIC IRRIGATION POND,
Tsukuba Univ., Ibaraki (Japan). Inst. of Biological Sciences.
H. Kang, and H. Seki.
Archiv fur Hydrobiolgie, Vol. 98, No. 1, p 39-58, September, 1983. 20 Fig, 19 Ref. Japanese Ministry of Education grant 57480004.

Descriptors: *Population dynamics, *Irrigation ponds, *Bacteria, Shin-ike Pond, Japan, Seasonal variations, Water temperature, Temperature effects, Mesotrophic lakes, Irrigation water, Plankton.

Shin-ike Pond is a shallow freshwater irrigation pond, typical in Japan, located on the northern slope of the small mountain, Shiroyama in Tsukuba District, Ibaraki Prefecture, Japan. Water samples were collected from the pond twice a week, from 6 March 1981 to February 1982, at depths of 0, 50 and 100 cm. The percentage of gram-negative forms in the bacterial communities of Shin-ike Pond fluctuated seasonally. Maximal percentages of gram-negative bacterioplankton were noted in March, June, November and February, and minima in May, August and December. Attached bacteria showed maxima in March, May, July, November and February, and minima in April, June, August, and December. A considerable fraction of the bacterioplankton community in the pond was gram-negative at any season. Utilization of dissolved organic materials by gram-negative bacteria was directly related to the availability of organic materials from phytoplankton. Such organic solutes were assimilated readily as soon as they were excreted by the phytoplankton. (Baker-IVI)
W84-02549

NUTRIENT UPTAKE BY PHYTOPLANKTON IN A MESOTROPHIC IRRIATION POND IN JAPAN,
Tokyo Univ. (Japan). Ocean Research Inst.
Y.-I. Nakamura, T. Hirano, Y. Hara, and H. Seki.
Archiv fur Hydrobiolgie, Vol. 98, No. 1, p 59-69, September, 1983. 6 Fig, 22 Ref. Japanese Ministry of Education grant 574800004.

Descriptors: *Nutrients, *Mesotrophic lakes, *Irrigation ponds, Phytoplankton, Japan, Shin-ike Pond, Irrigation water, Ponds, Chlorophyll, Nitrogen, Metabolism.

The seasonal variation of chlorophyll concentration in Shin-ike Pond showed that different species of phytoplankters seem to have appeared alternately in moderately high densities and to have bloomed in spring, summer and autumn. No bloom was noted during the winter months. The predominant species of the chlorophyll-b group in these phytoplankters were Crucigenia tetrapedia, Scenedesmus quadricauda, S. acuminantus, Scenedesmus sp., Euglena gigas, Euglena sp., Trachelomonas oblonga, Trachelomonas sp., and those of the chlorophyll-c group were Synedra, Mallomonas, Chromulina, Chrysococcus, Kephyrion, Peridinium, Gonyostomum semen, and Cryptomonas species. The standing stock could be expressed as a hyperbola relative to the inorganic nitrogen. That is, the threshold concentration for the uptake of inorganic nitrogen was between 1/4 and 1/2 of that needed to maintain the steady state population density in the pond. On the other hand, the nutrient uptake system of chlorophyll-b containing organisms was not active. The concentration of inorganic nitrogen was always high, between 9 and 30 micrograms N per liter, when they were predominant. (Baker-IVI)
W84-02550

TRANSIENT MEROMIXIS AND RELATED CHANGES OF EUTROPHICATION PARAMETERS IN A SMALL POLYTROPHIC LAKE IN SOUTHWEST GERMANY,
Tuebingen Univ. (Germany, F.R.). Fakultaet fuer Biologie.
V. Kracht.
Archiv fur Hydrobiologie, Vol. 98, No. 1, p 93-114, September, 1983. 16 Fig, 6 Tab, 50 Ref.

Descriptors: *Eutrophication, *Lake Stadtsee, *Cyanophyta, *Meromixis, Nutrient cycling, Phytoplankton, Nitrogen, Phosphorus, Oscillatoria, Climate.

For several hundred years Lake Stadtsee has been polluted by sewage loading from the surrounding city Bad Waldsee. In the last decades the lake showed polytrophic conditions with annual bluegreen algal blooms. Nutrient cycles and development of phytoplankton in Lake Stadtsee were studied from March 1980 to March 1982. During an extreme bloom of Oscillatoria Redekei during thermal stratification in summer 1980, inorganic nitrogen, phosphate and other eutrophication-indicating substances of the epilimnetic layer were largely depleted. The enrichment of these substances was measured in the anaerobic hypolimnion. In spring 1981 the usually dimictic Lake Stadtsee showed a meromixis, and the internal loading of the trophogenic zone was suspended. The transient meromixis in March 1981 was only a temporary event, and should be called transient partial circulation. Extraordinary climatic conditions were responsible for this event. Phytoplankton biomass the following summer was reduced to less than 0.5% of the values for 1980. The amount of blue-green algae decreased completely after springtime. While extraordinary enrichment of nutrients could be measured in the hypolimnion, the epilimnetic content of inorganic nitrogen and phosphate was also higher than the year before, resulting from the reduced demand by phytoplankton. The reduced development of algae is interpreted as a result of the suspended internal nutrient cycle. (Moore-IVI)
W84-02551

LONG-TERM POPULATION DYNAMICS AND PRODUCTION OF PISIDIUM (BIVALVIA) IN THE PROFUNDAL OF LAKE ESROM, DENMARK,
Joensuu Univ. (Finland). Dept. of Biology.
I. J. Holopainen, and P. M. Jonasson.
Oikos, Vol. 41, No. 1, p 99-117, 1983. 18 Fig, 6 Tab, 65 Ref.

Descriptors: *Pisidium, *Mollusks, *Population dynamics, *Lake Esrom, *Denmark, Eutrophic lakes, Reproduction, Dissolved oxygen, Hypolimnion, Growth, Water temperature, Mortality.

During the 21 years (1953-1973, 1976-1977) of routine quantitative sampling reported in this paper, three species of Pisidium (P. casertanum, P. substruncatum and P. henslowanum) have been present in the profundal of the eutrophic Lake Estrom, Denmark. From 1955 to 1962 P. casertanum was numerically dominant (peak density of 3273 ind/sq m was attained in 1957), at other times P. substrucatum dominated (peak 3025 ind/sq m in 1955). Since 1957-1958 the densities of both species have been below 1000 ind/sq m. The peak density of P. henslowanum (370 ind/sq m) was attained in 1957. All the species laid their eggs in spring (April-May), but the young were not released until the following winter, the exact time depending on the temperature and oxygen conditions. Only some of the eggs laid developed into young, and the size of the brood was dependent on parental size. The young reached maturity at the age of 2 yr, and a maximum life-span of 4-5 yr is suggested. The regularly occurring oxygen deficiency in the hypolimnion in summer caused heavy mortality in the dominant species and halted growth of individuals. Both the standing crop and annual production were lower in the population of P. subtruncatum, which is a smaller species. The annual P/B-ratios were ca. 1 in both the dominant populations. (Author's abstract)
W84-02554

THE ROLE OF FLAGELLATED PHYTOPLANKTON IN CHAINS OF SMALL BROWN-WATER LAKES IN SOUTHERN FINLAND,
Maj and Tor Nessling Foundation, Helsinki (Finland).
V. Ilmavirta.
Annales Botanici Fennici, Vol. 20, No. 2, p 187-195, 1983. 7 Fig, 4 Tab, 13 Ref.

Descriptors: *Flagellates, *Phytoplankton, *Chain lakes, *Finland, Color, Oligotrophic lakes, Mesoeutrophic lakes, Cryptomonads, Chrysomonads, Biomass, Solar radiation.

Small forest lakes are an important part of the Finnish environment. Typical of many forest lakes is brown water color, a relatively low pH, a shallow epilimnion and photosynthetic layer, and frequent oxygen depletion in the hypolimnion. These lakes often form chains, the water running from lake to lake. The biomass and species composition of the phytoplankton were studied together with some chemical parameters in 32 brown-water lakes in southern Finland, during three open-water periods. The waters form four lake chains, and the results are presented as the means of the chains. Of the lake chains, two are meso-eutrophic, two oligotrophic. Flagellated species made important contributions to the biomass in two of the brown-water chains, where cryptomonads and chrysomonads predominated. Flagellates compose more than 50% of the biomass when the color of the water is more than 50 mg Pt/l. Light seems to be the major factor regulating productivity. The high phytoplankton productivity in extremely oligotrophic brown lakes may be due to the migration of flagellates through the thermocline to take up additional nutrients from the hypolimnion and migration back to the illuminated layer for assimilation. (Moore-IVI)
W84-02610

SUBMERSED MACROPHYTE VEGETATION AND DEPTH DISTRIBUTION IN CHENANGO LAKE, NEW YORK,
State Univ. of New York at Binghamton. Dept. of Biological Sciences.
J. E. Titus.
Bulletin of the Torrey Botanical Club, Vol. 110, No. 2, p 176-183, April-June, 1983. 4 Fig, 1 Tab, 22 Ref.

Descriptors: *Aquatic plants, *Water depth, *Chenango Lake, *New York, *Macrophytes, Littoral zone, Vegetation, Submerged plants, Depth distribution.

Sixteen submersed taxa occurred in 900 0.15 sq m sample plots in Chenango Lake, a small (12.2 ha), shallow (mean depth = 1.76 m), alkaline lake. The most frequently encountered species were Chara vulgaris L. (73.1% frequency), Vallisneria americana Michx. (47.7%), and Potamogeton amplifolius Tuckerm, (38.8%). Other species with a frequency greater than 20% were Elodea canadensis Michx., Myriophyllum exalbescens Fern., and P. praelongus L. A vegetation map derived from transect data demonstrated that ca. 35% of the littoral zone sampled was dominated by Chara vulgaris, ca. 29% by Vallisneria americana, and ca. 21% by P. amplifolius. An unusual pattern of alternating bands of C. vulgaris and V. americana with increasing depth was observed. Considerable overlap exists in the depth ranges of the six most frequent species, but these species do differ significantly in the overall patterns of their depth distributions according to pairwise chi-square tests. Vallisneria americana showed its highest frequencies from 0.5-2.5 m, Chara vulgaris from 1-6 m, Elodea canadensis from 1-5 m, Potamogeton amplifolius from 1.5-5.5 m, Myriophyllum exalbescens from 2-5 m, and P. praelongus from 2-5.5 m. Chara vulgaris was significantly positively associated with all of the other most frequent species except Vallisneria americana. Potamogeton praelongus also registered positive associations with P. amplifolius and Myriophyllum exalbescens. In contrast, Vallisneria was negatively associated with both P. praelongus and M. exalbescens. The biological basis for observed distribution patterns is not yet known. (Author's abstract)
W84-02621

COMPLEXATION OF COPPER OF AQUATIC HUMIC MATTER STUDIED BY REVERSED-PHASE LIQUID CHROMATOGRAPHY AND ATOMIC ABSORPTION SPECTROSCOPY,
Sentralinstitutt for Industriell Forskning, Oslo (Norway).
G. Becher, G. Oestvold, P. Paus, and H. M. Seip.
Chemosphere, Vol. 12, No. 9, p 1209-1215, 1983. 2 Fig, 2 Tab, 11 Ref.

Descriptors: *Copper, *Natural waters, *Speciation, Humic acids, Decomposing organic matter, Atomic absorption spectroscopy, Metals, Complexation, Ions, Polarity, Geochemistry.

A combination of reversed-phase liquid chromatography and flameless atomic spectroscopy was used to study the speciation of copper in water containing natural organic compounds. The major part of the metal is found as ionic or highly polar complexes, but significant amounts are also found in fractions containing less polar compounds. In spite of certain limitations the method should be useful as a supplement to other techniques for studying metal complexation in natural waters. Humus water collected from Hellerudmyra near Oslo, Norway, was filtered and concentrated. The concentration of Cu in the final sample was adjusted to 2.6 ppm. Samples from Lake Ringvatnet near Trondheim, Norway were obtained from 1 m depth. (Baker-IVI)
W84-02631

PARTICULATE FLUX AT THE BOTTOM OF LAKE ONTARIO,
National Water Research Inst., Burlington (Ontario).
F. Rosa, J. O. Nriagu, and H. K. Wong.
Chemosphere, Vol. 12, No. 9/10, p 1345-1354, 1983. 3 Fig, 2 Tab, 17 Ref.

Descriptors: *Lake Ontario, *Particulates, *Lake sediments, Resuspension, Samplers, Water currents, Organic matter, Degradation, Trace metals, Fate of pollutants.

A special resuspension sediment sampler (RSS) was built and installed at an offshore station in the Western Basin of Lake Ontario during the summer

of 1981. The RSS carried an array of cylindrical traps at seven depths varying from 0.2 to 7 m above the sediment-water interface. Time-series sediment traps deployed at closely spaced intervals near the bottom of Lake Ontario show that the amount of material collected decreases exponentially with increasing distance from the sediments. At heights of 0.2 and 7 m above the bottom about 85% and 45% respectively of the suspended tripton is recruited from the sediments. The upward flux of particles is strongly correlated with speed of bottom currents, and the turn-over rate for particles at the sediment-water interface is estimated to be only a few hours. Near the bottom of Lake Ontario, the downward flux of particulate matter is small compared to the rate of sediment resuspension. The intense resuspension of sediments apparently affects the zone. A large fraction of the organic matter falling through the water column is degraded in the bottom waters containing the resuspended sediments. The constant resuspension of sediments should also play an important role in the removal of pollutant metals from the water column. The resuspension process can resolve a number of puzzling features pertaining to the distribution of pollutant metals in the Great Lakes sediments, including the movement of sediment-bound pollutants, the mixing layer, and the variability in the trace metal profiles in Great Lakes sediments. (Moore-IVI)
W84-02633

AN IMPROVED TECHNIQUE FOR ESTIMATING MEAN DEPTH OF LAKES,
Corvallis Environmental Research Lab., OR.
J. M. Omernik, and A. J. Kinney.
Water Research, Vol. 17, No. 11, p 1603-1607, 1983. 4 Fig, 1 Tab, 9 Ref.

Descriptors: *Lakes, *Water depth, Planimetry, Dot grid method, Measurment methods, Lake morphometry, Mapping, Bathimetry.

A technique is described for determining mean lake depth utilizing a systematically aligned dot grid. The dot grid pattern is placed over the bathymetric lake map, and the depth corresponding to each dot falling within the shoreline of the lake was estimated by visually interpolating between the contour lines. The depth readings were recorded, summed, and the total divided by the number of dot readings recorded to obtain the mean depth of the lake. Differences in map scale, and lake size and complexity, necessitate the use of different dot grid spacings. The technique is, on average, 55% faster than the traditional planimeter methods. No detectable bias is associated with results from this technique compared with those of traditional planimeter methods. The dot grid technique requires a relatively routine arithmetic process and no mechanical devices. Factors affecting the utility of the dot grid for estimating mean depth are: the user's ability to interpolate values; contour interval; and map scale. Map scale should be consistent with lake size; but, in general the larger the map scale the greater the level of detail represented, hence the greater the utility of the dot planimeter. (Moore-IVI)
W84-02707

RELATIONSHIP OF MATERIALS IN FLOODED SOILS AND SEDIMENTS TO THE WATER QUALITY OF RESERVOIRS-I; OXYGEN CONSUMPTION RATES,
Army Engineer Waterways Experiment Station, Vicksburg, MS. Environmental Lab.
D. Gunnison, R. L. Chen, and J. M. Brannon.
Water Research, Vol. 17, No. 11, p 1609-1617, 1983. 3 Fig, 6 Tab, 28 Ref.

Descriptors: *Reservoirs, *Sediments, *Flooded soils, *Oxygen consumption, Microorganisms, Aquatic sediments, Leaching, Degradation, Temperature effects.

Oxygen consumption rates were obtained for four soils and six reservoir sediments using sediment-water reaction chambers and a differential respirometer. Determination of microbial activity as measured by (C-14)glucose metabolism was also performed on these soils and sediments. To study the transformation of newly flooded soils into aquatic sediments, the effects of prolonged submergence and temperature upon oxygen consumption, carbon dioxide formation and methanogenesis were examined. Newly flooded soils initially had high biological oxygen consumption rates, ranging from 67.2 to 76.6% of the total oxygen demand. Established reservoir sediments, in contrast, exhibited extremely high chemical oxygen demands, ranging from 62.7 to 89.9% of the total oxygen demand and had proportionately lower biological oxygen demands. Newly flooded soils had the capacity for high rates of oxygen consumption, carbon dioxide formation, and methanogenesis. These rates were extremely temperature-dependent and subject to rapid decline with prolonged submergence due to leaching and degradation of biologically available organic carbon (BAOC). With aging, the amount of BAOC released from the flooded soils decreased, the proportion of reduced inorganic chemical species increased, and a distinct aerobic-anaerobic double layer developed at the soil surface during aerobic conditions in the overlying water column. In reservoirs, the process is complicated by reservoir hydrodynamics and morphometric properties which tend to move waters of poor quality out of the system with subsequent downstream effects. (Moore-IVI)
W84-02708

COMPARISONS OF TROPHIC STATE MEASUREMENTS,
Environmental Monitoring Systems Lab., Las Vegas, NV.
V. W. Lambou, W. D. Taylor, S. C. Hern, and L. R. Williams.
Water Research, Vol. 17, No. 11, p 1619-1626, 1983. 4 Tab, 34 Ref.

Descriptors: *Lakes, *Trophic level, *Phosphorus, *Chlorophyll a, Nutrients, Eutrophication, Secchi disks, Kjeldahl nitrogen, Phytoplankton, Algae.

Twenty-nine methods commonly used to measure trophic state were compared with respect to their ability to rank 44 test lakes against two standards: total phosphorus, a nutrient or driving force standard and chlorophyll a, an eutrophication response standard. The phosphorus loading models had high rank correlations with phosphorus; however, they did not rank the lakes well against chlorophyll. The relative trophic ranking of many lakes differed depending upon whether primary nutrients or biological manifestations were used as the ranking mechanism. Secchi disk was very effective in ranking the lakes against phosphorus but was relatively ineffective in ranking them against chlorophyll. Total Kjeldahl nitrogen was effective in ranking the lakes against phosphorus and had the highest rank correlation of all the methods tested against chlorophyll. Methods based upon phytoplankton community structure were especially ineffective in ranking the test lakes. Algal assay control yield gave disappointing results when compared against the chlorophyll standard. Most methods were much more effective in ranking the lakes against the total phosphorus standard than the chlorophyll a standard. (Author's abstract)
W84-02709

INDIAN CREEK RESERVOIR SEDIMENTS,
Utah State Univ., Logan. Dept. of Civil and Environmental Engineering.
V. D. Adams, M. L. Cleave, J. R. Cofer, and E. J. Middlebrooks.
Water Research, Vol. 17, No. 11, p 1709-1712, 1983. 1 Fig, 5 Tab, 18 Ref.

Descriptors: *Reservoirs, *Sediments, *Indian Creek Reservoir, *Effluents, Advanced wastewater treatment, Eutrophic lakes, Phosphorus, Carbon, Nitrogen, Chlorophyll.

Indian Creek Reservoir (ICR) was originally designed to hold the effluent from the South Tahoe Public Utility District (STPUD) advanced wastewater treatment plant during the winter months and to release the impounded water during the irrigation season. The original use of the reservoir has been modified extensively, and in addition to the agricultural uses, the reservoir has become a popular recreational facility. Changes in the use of the reservoir have resulted in changes in the standards imposed upon the STPUD and ICR. Because of the unique nature of the influent to ICR, unusual claims are frequently made about the characteristics of the water and sediments. The question is frequently asked if the sediments in ICR differ from those found in other eutrophic lakes or reservoirs. Sediment samples were collected from four diverse sites in the reservoir. The samples were analysed for phosphorus, carbon, nitrogen, volatile content, and chlorophyll content. The results of the analyses showed that the sediments are typical of those found in any eutrophic lake or reservoir. (Author's abstract)
W84-02715

THE DYNAMICS OF SUSPENDED ALGAL POPULATIONS IN THE LOWER WYE CATCHMENT,
Welsh Water Authority, Powys (Wales).
F. H. Jones.
Water Research, Vol. 18, No. 1, p 25-35, 1984. 5 Fig, 5 Tab, 24 Ref.

Descriptors: *Algae, *Population dynamics, *Lugg, *Wye, England, Solar radiation, River flow, Scenedesmus, Cyclotella, Filter feeders, Water treatment, Taste, Odor, Deoxygenation, Haloforms.

The algae of the River Wye and its tributary the River Lugg were described principally from samples collected from 7 sites in the lower Wye catchment during 1980 and 1981. The density of algae in the Wye was found to be correlated with river flow and solar radiation, highest numbers (1,250,000 cells/ml), principally of Scenedesmus and Cyclotella, occurring at low stable flows and relatively high solar radiation. Algal populations in the Lugg were much smaller (<1,300 cells/ml) than those of the Wye and were principally composed of species derived from the periphyton. Downstream increases in load (cell density x flow) of both Scenedesmus and Cyclotella in the Wye were generally equivalent to about 0.3 division/d; these rates were lower than those obtained in laboratory culture and this was probably largely related to underestimates arising from algal removal by filter feeders (principally simuliid larvae). Potential problems arising from the treatment of Wye water supporting substantial algal growths are considered; these include haloform production, deoxygenation in a transfer pipeline, algal penetration into potable supply and taste and odor. (Author's abstract)
W84-02738

THE INTERACTION OF LAKES WITH VARIABLY SATURATED POROUS MEDIA,
Geological Survey, Denver, CO.
For primary bibliographic entry see Field 2F.
W84-02764

THE ROLE OF BENTHIC MACROINVERTEBRATES IN DETRITUS DYNAMICS OF STREAMS: A COMPUTER SIMULATION,
Oak Ridge National Lab., TN. Environmental Sciences Div.
J. R. Webster.
Ecological Monographs, Vol. 53, No. 4, p 383-404, December, 1983. 13 Fig, 5 Tab, 112 Ref.

Descriptors: *Invertebrates, *Detritus, *Simulation, *Computer models, Stream dynamics, Stream order, Particulates, Organic matter, Storms, Big Hurricane Branch, North Carolina.

Detritus dynamics in Big Hurricane Branch, a second-order stream at Coweeta Hydrologic Laboratory (North Carolina) in the southern Appalachian Mountains, were simulated with a computer model, using data from a variety of Coweeta stream studies. The model was used to evaluate the role of macroinvertebrates in the stream. Macroinvertebrates accounted for only a small portion of the respiration of detritus; their major role was conversion of benthic detritus into transported detritus. Macroinvertebrates were responsible for

27% of annual particulate organic matter (POM) transport, though when they were removed there was only a 10% reduction in POM transport because of a compensatory increase in storm transport. The contribution of macroinvertebrates to POM transport during nonstorm periods was much more significant, as high as 83% in late summer. Based on an annual budget, macroinvertebrates decrease the efficiency of detritus processing in low-order streams, because they increase transport loss. On a longer time scale, however, macroinvertebrates prevent accumulation of large amounts of detritus in the stream and major losses during infrequent large storms. By stabilizing long-term detritus export dynamics, they provide an important link between low-order and higher-order streams. (Author's abstract)
W84-02776

VARIABILITY OF WATER TEMPERATURES IN THE BRAIDED ASHLEY AND RAKAIA RIVERS,
Ministry of Works and Development, Christchurch (New Zealand).Water and Soil Science Centre.
M. P. Mosley.
New Zealand Journal of Marine and Freshwater Research, Vol. 17, No. 3, p 331-343, 1983. 9 Fig, 1 Tab, 11 Ref.

Descriptors: *Water temperature, *Ashley River, *Rakaia River, *New Zealand, Braided rivers, Seasonal variation, Groundwater, Underflow seepage, Fish.

Water temperatures were measured throughout the day in selected branch channels of the Ashley and Rakaia Rivers, on days near midwinter, midsummer, and the equinox. At any 1 time, water temperatures in the channels varied over several degrees; the maximum range observed was between 17.2 and 35 C in the Ashley River at 1400 h in December 1982. Without interchange with groundwater, rate of downstream increase in temperature is theoretically proportional to phi sub net, the net heat exchange at the water surface, and Q(-0.067), where Q is discharge, so that smaller channels should have a greater rate of temperature increase (and therefore, higher temperatures) than larger channels. However, it was commonly observed that small channels had lower temperatures than the main channel, because of the seepage of cool underflow from the streambed. Up to 40% of the total water surface area may have temperatures several degrees cooler than the main channel; this may represent potential refuges for fish for which the high temperatures elsewhere would be lethal. (Author's abstract)
W84-02838

STUDIES ON THE DETERMINATION OF DISSOLVED OXYGEN IN WATER,
Health and Welfare Canada, Ottawa (Ontario). Health Protection Branch.
M. Malaiyandi, and V. S. Sastri.
Talanta, Vol. 30, No. 12, p 983-985, 1983. 3 Fig, 1 Tab, 14 Ref.

Descriptors: *Dissolved oxygen, *Chemical properties, Anions, Ethylenediaminetetra-acetate, Cyclohexanediaminetetra-acetate, Oxygen balance.

Studies on the decomposition rates of the Mn(III) complex of cyclohexanediaminetetra-acetate (DCTA) in light and in darkness show that this complex is more stable than the one derived from ethylenediaminetetra-acetate. The optimum pH range for the determination of dissolved oxygen by means of the Mn(III)-DCTA complex is between 3 and 4. The absorbance of this complex is independent of the amount of DCTA used (in the range 0.2-1.0 g) with water samples containing a maximum of 3.2 ppm of dissolved oxygen. Significant interferences are caused by the presence of anions at 500 times the oxygen concentration. (Murphy-IVI)
W84-02912

SENSITIVITY OF LAKES TO INORGANIC ENRICHMENT STRESS - SOME RESULTS OF EXPERIMENTALLY INDUCED FERTILIZATION,
Polish Academy of Sciences, Warsaw.
A. Hillbricht-Ilkowska, and B. Zdanowski.
Internationale Revue der Gesampten Hydrobiologie, Vol. 68, No. 2, p 153-174, 1983. 8 Fig, 4 Tab, 33 Ref.

Descriptors: *Lake sensitivity, *Inorganic enrichment, *Stress analysis, *Induced fertilization, Eutophication, Phosphorous, Nitrogen, Deposition.

The introduction of P and N loads exceeding 4-14 and 1-2 times, respectively, and the amount of these nutrients stored in the waters of four lakes (dystrophic and eutrophic, stratified and unstratified) resulted in stronger, two-phased changes in Ptot standing stock and in rather insignificant and non-directed changes in Ntot in all lakes. There was an immediate increase of Ptot which followed by a decrease in Ptot together with a decrease in the N:P ratio. The final level was higher than in the control. The top layer of off-littoral sediments had a temporary accumulation of nutrients followed by their release to a level significantly lower than that in the control year. Visible changes in the nutrient content and total biomass of above-ground parts of macrophytes were only in the lake which was previously highly dystrophic, after it had been limed. This lake reacted strongest to the P load, and the release of nutrients from its deposits started simultaneously with fertilization. The reduction in the N:P ratio in the lake waters was mainly responsible for the lack of assimilation of further doses of P. The acceleration of denitrification process caused by the higher overall lake productivity was responsible for the stabilization and removal of the N load. The activation of bacterial decomposition in the sediments due to the increase in lake productivity and sedimentation rate was the probable reason for the acceleration of the nutrients release from the top layers of the sediments and their further physical transport to deeper layers. (Murphy-IVI)
W84-02949

2I. Water In Plants

CARBOHYDRATE PARTITIONING IN RELATION TO WHOLE PLANT PRODUCTION AND WATER USE OF VIGNA UNGUICULATA (L.) WALP.,
Bayreuth Univ. (Germany, F.R.). Lehrstuhl fuer Pflanzenoekologie.
E.-D. Schulze, K. Schilling, and S. Nagarajah.
Oecologia, Vol. 58, No. 2, p 169-177, May, 1983. 10 Fig, 17 Ref, 1 Append.

Descriptors: *Water requirements, *Plant growth, *Carbohydrates, Biomass, Transpiration, Roots, Leaves, Carbon, Evapotranspiration.

Experiments with Vigna unguiculata at two levels of evaporative demand and two levels of water uptake capacity of the root were undertaken to analyze carbon partitioning patterns with respect to water utilization. Theoretical considerations were made based upon optimization theory, especially by application of the Pontryagin Maximum Principle, that in some cases carbohydrate partitioning is dependent upon the transpiration rate per leaf weight and upon the efficiency of the root at taking up water. Growth of V. unguiculata at two levels of air humidity and water uptake rate was consistent with such a carbohydrate partitioning pattern. Growth of total biomass and its components (leaves, stems, and roots), whole plant transpiration, and the pattern of carbon partitioning were predicted and explained by applying the foregoing principles of optimization in a heuristic model for vegetative growth of an animal. (Baker-IVI)
W84-02489

ROOTING PATTERN AND WATER RELATIONS OF THREE PASTURE GRASSES GROWING IN DRYING SOIL,
Lancaster Univ., Bailrigg (England). Dept. of Biological Sciences.
D. E. Molyneux, and W. J. Davies.
Oecologia, Vol. 58, No. 2, p 220-224, May, 1983. 5 Fig, 1 Tab, 19 Ref.

Descriptors: *Grasses, *Water requirements, Plant growth, Water stress, Roots, Turgor, Water deficit, Soil water.

The water relations and rooting patterns of three common pasture grasses were examined to determine if turgor maintenance in roots can act to maintain or even promote the growth of roots in drying soil. The effects of water deficit on the absolute length of root and the rooting patterns of the grasses were also determined. Root turgor of Dactylis was larger than that of Lolium and Phleum. As a result of accumulation of solutes, turgor of Dactylis and Lolium was maintained as the soil dried. Phleum roots lost turgor in drying soil and this characteristic correlated well with a water stress induced reduction in root and shoot growth. Soil drying had marked effects on the rooting patterns of two of the three species. Phleum seedlings which in wet soil are deep rooting were restricted in their depth of rooting, while roots of water stressed Dactylis seedlings grew deeper into the profile than did roots of well watered plants. When water was withheld from plants, deeper rooting apparently resulted in a more favorable shoot water balance which had a beneficial effect on shoot growth. (Baker-IVI)
W84-02490

DROUGHT RELATIONS OF SHRUB SPECIES: ASSESSMENT OF THE MECHANISMS OF DROUGHT RESISTANCE,
Washington Univ., Seattle. Coll. of Forest Resources.
T. M. Hinckley, F. Duhme, A. R. Hinckley, and H. Richter.
Oecologia, Vol. 59, No. 2-3, p 344-350, 1983. 4 Fig, 4 Tab, 29 Ref.

Descriptors: *Drought resistance, *Shrubs, Plant water potential, Root distribution, Osmotic potential, Stomata, Water stress.

Relatively static factors such as depth of rooting and cuticular conductance and relatively dynamic factors such as stomatol control and changes in the components of water potential were used to assess the drought resistance characteristics of six deciduous shrub species. Predawn water potential during a prolonged drought averaged -2.13 and -3.51 MPa in species known to have deep and shallow patterns of rooting, respectively. It is thus surprising that the osmotic potential at the turgor loss point averaged only -3.01 MPa in the shallow rooted group. The water potential at which irreversible cell damage occurred was the same in both groups (04.9 MPa), and minimum values observed in the field never dropped below -4.0 MPa. There was, however, a pronounced difference between the two groups with regard to stomatal behavior. This allowed us to characterize the deep-rooted species as avoiders of stress which cause prolonged stomatal closure whereas the shallow-rooted species had to tolerate prolonged periods of closed stomata. (Author's abstract)
W84-02491

EXPERIMENTAL REMOVAL OF INTRASPECIFIC COMPETITORS - EFFECTS ON WATER RELATIONS AND PRODUCTIVITY OF A DESERT BUNCHGRASS, HILARIA RIGIDA,
California Univ., Los Angeles. Dept. of Biology.
R. Robberecht, B. E. Mahall, and P. S. Nobel.
Oecologia, Vol. 60, No. 1, p 21-24, 1983. 5 Fig, 1 Tab, 17 Ref.

Descriptors: *Soil-water-plant relationships, *Competition, *Hilaria, *Productivity, Soil water potential, Deserts, Growth, Biomass, Root development, Sonoran Desert, California.

Intraspecific competition in the C4 bunchgrass Hilaria rigida was examined on a Sonoran Desert site in southeastern California. Potential competition within monospecific stands was experimentally altered by removal of the aboveground portions of all plants within a 1.5 m radius of a monitored plant. Compared with unaltered plots, altered plots had less negative soil water potentials during period of soil drying. Leaf blades on monitored

plants of altered plots remained green longer and had greater stomatal conductances than those on monitored plants on unaltered plots. Production of new culms was twice as great on altered plots. Greater root biomass and root length were observed in altered plots, and root extension into soil areas formerly occupied by roots of neighboring plants occurred within one year after treatment. The results indicate that removal of the aboveground biomass of neighboring plants reduces the competition for limited available soil water in this desert environment. (Author's abstract)
W84-02495

STRESS-INDUCED RIPENING OF THE NON-RIPENING TOMATO MUTANT NOR,
Ben-Gurion Univ. of the Negev, Beersheba (Israel). Applied Research Inst.
S. M. Arad, and Y. Mizrahi.
Physiologia Plantarum, Vol. 54, No. 2, p 213-217, October, 1983. 2 Fig, 4 Tab, 12 Ref.

Descriptors: *Water stress, *Tomatoes, *Ripening, Drought, Transpiration, Kinetin, Fruit.

Tomato (Lycopersicon esculentum Mill.) plants of the non-ripening mutant nor (3rd backcross to the normal cultivar Rutgers) were grown under water stress induced in two different ways: a) reduction of water supply and b) increase in transpiration rate by adding kinetin to the nutrient solution. Both drought treatments induced fruits of the non-ripening mutant nor to ripen, that is, the parameters characteristic of ripening - red pigment, taste, pectolytic activity, softening, and the evolution rates of CO2 and ethylene - all increased, although not to the normal level. Such an increase does not normally take place in the nor mutant under control conditions. It is suggested that fruits of the nor mutant can be induced to ripen by any kind of water stress. The induction mechanism is still to be explored. (Author's abstract)
W84-02499

FURTHER STUDIES IN FLOOD TOLERANCE OF BETULA PAPYRIFERA SEEDLINGS,
Wisconsin Univ.-Madison. Dept. of Forestry.
Z. C. Tang, and T. T. Kozlowski.
Physiologia Plantarum, Vol. 59, No. 2, p 218-222, October, 1983. 1 Fig, 4 Tab, 27 Ref.

Descriptors: *Flooding, *Seedlings, *Birch trees, Roots, Adventitious roots, Growth, Flood tolerance.

Flooding of soil for 60 days drastically reduced height growth, cambial growth, dry weight increment, and relative growth rate of 150-day-old Betula papyrifera Marsh seedlings. Comparisons of responses to flooding of 150-day-old and 230-day-old seedlings indicated important differences between the two age classes. Whereas the younger seedlings produced abundant adventitious roots on submerged portions of stems, the older seedlings did not. Flooding also induced much more leaf abscission in the older seedlings. Flooding generally reduced root-shoot ratios of both age classes, largely as a result of inhibition of growth and decay of root systems. However, root-shoot ratios were altered appreciably by formation of adventitious roots in the younger seedlings and by extensive leaf abscission in the older seedlings. (Author's abstract)
W84-02500

RESPONSES OF LOBLOLLY PINE (MESOPHYTE) AND SWAMP TUPELO (HYDROPHYTE) SEEDLINGS TO SOIL FLOODING AND PHOSPHORUS,
Clemson Univ., SC.
D. D. Hook, D. S. Debell, W. H. McKee, Jr., and J. L. Askew.
Plant and Soil, Vol. 71, No. 1-3, p 387-394, 1983. 2 Fig, 1 Tab, 15 Ref.

Descriptors: *Flooding, *Seedlings, *Pine, *Tupelo, *Phosphorus, Nutrients, Anaerobic conditions, Growth, Iron.

In a pot study, flooding reduced growth of loblolly pine (LP) seedlings and caused an imbalance of nutrients, particularly Fe, in the tops. Swamp tupelo (ST) suffered none of these problems. Also under anaerobiosis, LP roots leaked 85% of total ethanol production into solution whereas ST leaked only 55%. Application of phosphorus increased LP growth under flooded and drained conditions but ST only under drained conditions. The differential response of the two species to flooding suggests that poor energetics and the leaky nature of LP roots under anaerobiosis restricts its growth in such habitats. Application of phosphorus (P) appears to amend these conditons in LP by reducing moisture stress, reducing nutrient imbalances, and improving energetics in older seedlings. ST, the hydrophyte, avoids the problems of soil flooding via adaptions in anaerobic metabolism and oxidation of the rhizosphere. (Author's abstract)
W84-02501

SOIL TEMPERATURE AND FLOODING EFFECTS ON TWO SPECIES OF CITRUS; I. PLANT GROWTH AND HYDRAULIC CONDUCTIVITY,
Agricultural Research and Education Center, Lake Alfred, FL.
J. P. Syvertsen, R. M. Zablotowicz, and M. L. Smith, Jr.
Plant and Soil, Vol. 72, No. 1, p 3-12, 1983. 4 Fig, 2 Tab, 25 Ref.

Descriptors: *Soil temperature, *Flooding, *Citrus, *Growth, *Permeability coefficient, Lemon, Orange, Seedlings, Root conductivity, Plant water potential.

Rough lemon (Citrus jambhiri Lush.) and sour orange (C. aurantium L.) seedlings were grown at constant soil temperatures of 16, 24, and 33 degrees C for 3 months. Shoot and root growth of rough lemon was greatest at 33 degrees C while growth of sour orange was greatest at 24 degrees C. There were no significant effects of soil temperature on shoot : root ratio, leaf water potential or stomatal conductance. The hydraulic conductivity of intact root systems of both species was highest when seedlings were grown at 16 degrees C. Thus, acclimation through greater root conductivity at low soil temperature may have compensated for decreased root growth at 16 degrees C and negated effects of soil temperature on plant water relations. Half the plants growing at each soil temperature were subsequently flooded. Within 1 week, the soil redox potential (Eh) dropped below zero mV, reaching a minimum Eh of - 250mV after 3 weeks of flooded conditions. Flooded plants exhibited lower root conductivity, a cessation of shoot growth, lower leaf water potentials, lower stomatal conductances, and visual sloughing of fibrous roots. Decreases in root conductivity in response to flooding were large enough to account for the observed decreases in stomatal conductance. (Author's abstract)
W84-02502

RESPONSE OF UPLAND RICE VARIETIES TO DROUGHT STRESS; II. SCREENING RICE VARIETIES BY MEANS OF VARIABLE MOISTURE REGIMES ALONG A TOPOSEQUENCE,
International Inst. of Tropical Agriculture, Ibadan (Nigeria).
B. Mambani, and R. Lal.
Plant and Soil, Vol. 73, No. 1, p 73-94, 1983. 10 Fig, 8 Tab, 22 Ref.

Descriptors: *Rice, *Drought, *Water stress, Soil water, Water table, Root distribution, Soil-water-plant relationships.

The effects of variable soil moisture regimes also a toposequence on root development, plant water status, and grain yield were investigated for ten rice varieties: (1) 63-83, (2) IB43, (3) OS6, (4) IB6, (5) IR 1529-680-3, (6) C22, (7) IRAT-13, (8) TOS 4680, (9) IET 1444 and (10) SE302G. The depth of water table below the soil surface in three regions along the toposequence was 100 (M1), 30 (M2) and 15 cm (M3). Soil moisture regime did not affect total root dry weight significantly. However, depth of root penetration did vary for the different moisture regimes and varieties investigated. The angle of root penetration was also affected by soil moisture regime. Roots of tall varieties (63-83, IB6 and IRAT 13) penetrated deeper into the soil profile than short varieties. The pattern of soil moisture depletion was similar to that of root density profile. Relative water stress, expressed as a ratio of leaf water deficit under the M1 moisture regime to that under M3, increased exponentially with decrease in root density at a depth of 25 cm. The mean grain yield of ten varieties exhibited normal distribution under an adequate soil moisture regime (M1), the distribution pattern changed under the adverse regime. Variety IB6 and other tall varieties maintained stable yields under the adverse moisture regime. Grain yield was linearly related to root density at a depth of 25 cm. (Author's abstract)
W84-02504

RESPONSE OF UPLAND RICE VARIETIES TO DROUGHT STRESS; III. ESTIMATING ROOT SYSTEM CONFIGURATION FROM SOIL MOISTURE DATA,
International Inst. of Tropical Agriculture, Ibadan (Nigeria).
B. Mambani, and R. Lal.
Plant and Soil. Vol. 73, No. 1, p 95-104, 1983. 2 Fig, 7 Tab, 13 Ref.

Descriptors: *Rice, *Drought, *Soil water, *Root distribution, Soil water potential.

Root density profile of three varieties grown along a toposequence under three soil moisture regimes was estimated from soil moisture depletion patterns in the soil profile. Each of the three varieties, IB 6, IR 1529-680-3 and IET 1444, had a different rooting pattern. The three soil moisture regimes corresponded to water table depths of 100(M1), 30(M2) and 15 cm(M3) below the soil surface. Soil moisture potential was negatively correlated with root density, and the differences in rate of moisture depletion at various depths were due largely to differences in root activity. However, varietal differences in root activity were observable only within a narrow range of soil moisture potential, generally above -0.06 bar. The relationship between soil moisture status and root density distribution in the soil profile offers a quick means of estimating varietal differences in root activity at various depths. If evaporation can be minimized, and the soil is horizontally uniform, simultaneous measurements of the moisture status under bare and cropped plots may help to determine the maximum rooting depth accurately. (Moore-IVI)
W84-02505

DIURNAL AND SEASONAL WATER RELATIONS OF THE DESERT PHREATOPHYTE PROSOPIS GLANDULOSA (HONEY MESQUITE) IN THE SONORAN DESERT OF CALIFORNIA,
Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Biology.
E. T. Nilsen, M. R. Sharifi, P. W. Rundel, W. M. Jarrell, and R. A. Virginia.
Ecology, Vol. 64, No. 6, p 1381-1393, 1983. 11 Fig, 67 Ref. NSF grant DEB 79-21971.

Descriptors: *Mesquite, *Phreatophytes, *Water stress, *Seasonal variation, *Sonoran Desert, *California, Diurnal variation, Groundwater, Soil water potential, Transpiration, Soil-plant-water relationships, Plant water potential, Soil salinity, Stomata, Osmotic pressure, Water availability.

Prosopis glandulosa var. torreyana in the Sonoran Desert of southern California acquired its water from a ground water source 4-6 m deep. Harper's Well, the test site, lies at an elevation of -30 m at the base of the Fish Creek Mountains, 15 km west of the southern tip of the Salton Sea. Diurnal and seasonal cycles of aboveground environmental conditions, soil moisture, and soil water potential (to 6 m depth) were measured to determine environmental water availability and water stress. Leaf water potential, leaf conductance, leaf transpiration, relative saturation deficit of leaves, osmotic potential, and turgor potential were measured to evaluate plant adaptations to environmental water

stress. Soil water potential was low (-4.0 to -5.0 MPa) in surface soil in relation to deep soil (-0.2 MPa). The difference was due to high surface soil salinity and low surface water content. Climatic conditions at the research site produced extreme water stress conditions in summer months when temperatures reached 50 C, vapor pressure deficit (VPD) reached 8 kPa, and surface soil water potential was below -4.5 MPa. Considerable plant water stress developed in these trees (midday leaf water potential -4.8 MPa), but osmotic adjustment occurred and turgor was maintained on a diurnal and seasonal cycle. P. glandulosa has adapted to avoid water stress by utilizing deep ground water, but this phreatophyte has also evolved physiological adaptations, such as osmotic adjustment and seasonally changing stomatal sensitivity to VPD, which result in greater tolerance of water stress. (Moore-IVI)
W84-02541

2J. Erosion and Sedimentation

SOIL DISPERSIBILITY,
Wisconsin Univ.-Madison. Dept. of Soil Science.
A. Dong, G. Chesters, and G. V. Simsiman.
Soil Science, Vol. 136, No. 4, p 208-211, October, 1983. 4 Tab, 11 Ref. EPA grant R005142.

Descriptors: *Soil erosion, *Soil dispersibility, Sediment transport, Clay, Organic carbon, Simulation, Ultrasound, Soil properties.

Samples of six surface soils, two subsurface soils, and one organic soil from the Menomonee River Watershed, Wisconsin were dispersed by shaking with water to simulate natural water erosion and particle transport conditions, and ultrasound to provide complete dispersion. The shaking treatment consists of end-over-end agitation of a 1:10 wt:vol soil:water mixture for 0.5 to 128 hours, and the ultrasound treatment was for a 15-minute period. The ratio of the amount of clay-sized particles dislodged by shaking to the amount of clay-sized particles obtained by ultrasound treatment was used to measure ease of dispersibility of soils. Samples with clay-sized particles that disperse readily under the shaking treatment have a higher dispersibility ratio than samples with clay-sized particles that remain intact as aggregates, If a 4-hour shaking treatment simulates the onset of soil erosion conditions in the field, as much as 90% of the primary clay-sized particles remain intact as silt-sized or larger aggregates. The clay dispersibility ratio was significantly correlated with organic carbon content in an inverse relationship. The significant 1/x relationship between organic carbon content and clay dispersibility indicates that increasing organic matter content, for example by addition of sewage sludge, would increase aggregate stability of mineral soils. (Moore-IVI)
W84-02517

EFFECT OF FIRE ON HYDROPHOBIC AND CEMENTING SUBSTANCES OF SOIL AGGREGATES,
Consiglio Nazionale delle Ricerche, Pisa (Italy). Ist. per la Chimica del Terreno.
G. Giovannini, and S. Lucchesi.
Soil Science, Vol. 136, No. 4, p 231-236, October, 1983. 3 Tab, 18 Ref.

Descriptors: *Fires, *Hydrophobic soils, *Soil erosion, *Soil aggregates, Cementing substances, Organic matter, Sardinia, Italy.

Repeated fires are common on grassland during the Italian hot season. Some fires start accidentally, but most, especially on the Sardinian island, are set for the purpose of converting the Mediterranean chaparral to grassland for sheep grazing. Many Italian soils over which fire has passed are intensely eroded. To clarify the effect of fire on some factors associated with the soil erodibility, such as soil organic matter content, aggregate stability, and hydrophobic and cementing substances, an experimental burning was performed in a selected watershed characterized by surface layers of soil that repel water slightly. After the fire had passed, a decrease in soil organic matter content in the upper soil layers was noted, connected wih the disappearance of the resistance to wetting and with the lowering of the aggregate stability. The upper part of the underlying B horizons showed an accumulation of organic matter and an increase in aggregate stability. No evidence for soil hydrophobicity was detected, but the discrepancy may be explained by the fine texture of the soil tested. The deeper horizons were practically unaffected by the fire. (Moore-IVI)
W84-02518

GEOCHEMISTRY OF THE AMAZON; 2. THE INFLUENCE OF GEOLOGY AND WEATHERING ENVIRONMENT ON THE DISSOLVED LOAD,
Massachusetts Inst. of Tech., Cambridge. Dept. of Earth and Planetary Sciences.
For primary bibliographic entry see Field 2K.
W84-02560

CAUSES OF RIVER BED DEGRADATION,
For primary bibliographic entry see Field 8B.
W84-02753

SOIL LOSS-SEDIMENT YIELD TO SILVER LAKE, MISSOURI,
Soil Conservation Service, Columbia, MO.
V. L. Finney.
Bulletin of the Association of Engineering Geologists, Vol. 20, No. 4, p 405-409, November, 1983. 3 Fig, 7 Tab, 15 Ref.

Descriptors: *Silver Lake, *Missouri, *Soil loss, *Sediment yield, Sediment deposition, Drainage area, Soil erosion.

Silver Lake, approximately 3,050 acres, is the largest of three reservoirs in the Swan Lake National Wildlife Refuge, Missouri. A sedimentation survey, cesium 137 analyses, and soil loss calculations were used to estimate the average rate and variability in rates of sediment deposition in Silver Lake, and soil loss rates in the Silver Lake drainage area. The rates of soil loss and sediment deposition have been relatively constant since 1957. Silver Lake is estimated to be filling at an average rate of 43.75 acre ft. This rate gives an average annual water depth loss of 0.4 cm. If this rate of sedimentation is allowed to continue, Silver Lake will be filled with sediment in 280 yr. Continued sediment deposition in Silver Lake will induce flora and fauna changes. (Moore-IVI)
W84-02833

RIVERBANK EROSION - A CASE STUDY,
Louisville Univ., KY.
D. J. Hagerty, M. Sharifounnasab, and M. F. Spoor.
Bulletin of the Association of Engineering Geologists, Vol. 20, No. 4, p 411-437, November, 1983. 19 Fig, 33 Ref.

Descriptors: *Bank erosion, *Ohio River, *Kentucky, Water currents, Wind waves, Water level fluctuations, Precipitation, Alluvium, Floods, Boats, Waves.

A field study of riverbank erosion was carried out during a 13-month period at five sites along the Ohio River near Louisville, Kentucky. The soils at the sites consisted of layered alluvium; the fraction of total bank height composed of sandy layers varied widely from site to site. The influences of high-water currents, wind waves and vessel waves also varied from one location to another. Bank material loss/gain was measured by means of pins and tubes installed on a grid pattern, together with a base line, at each site. A regular program of photography at each site further depicted bank changes. Data were gathered on river level fluctuations and precipitation during the study. The severity of erosional loss appeared to depend principally on the bank materials; sandy banks retreated farthest during the study. Episodes of bank material loss coincided with periods of high water, particularly when bank materials were wetted by antecedent precipitation before flood events. Flow of water out of previous layers of alluvium was found to be a major factor in causing failure. Wave action was seen to be an insignificant cause of erosion at the five sites studied. (Author's abstract)
W84-02834

MEANDER BENDS OF HIGH AMPLITUDE,
Minnesota Univ., Minneapolis.
For primary bibliographic entry see Field 8B.
W84-02867

STATISTICAL PROPERTIES OF SEDIMENT MOVEMENT,
National Univ. of Singapore. Faculty of Engineering.
H.-F. Cheong, and H.-W. Shen.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1577-1588, December, 1983. 11 Fig, 10 Ref, 2 Append. NSF grant ENG-7825054.

Descriptors: *Sediment transport, *Dispersion, Statistical analysis, Dunes, Particulates, Time rate, Space rate, Rest duration, Step length.

The discrete unidirectional movement of a contaminated sediment particle along the bed of an alluvial channel is assumed to take place in a series of alternate rest and transport periods. On the assumption that the downstream dispersion of sediment bed particles can be represented by a stationary point process in space and time domains, plausible forms of the probability density functions of the particle step length and rest duration are derived from their corresponding rate parameters. Time rate parametric functions yield monotonically decreasing forms of density functions for rest durations. The proposed space rate parameter gives step length density functions whose form vary from the exponential curve to the bell-shaped configuration. Experimental evidence supports a bell-shaped form for step length density functions for tracer motion over a dune bed. The proposed time rate parameter and space rate parameter yielded rest duration and step length density functions which represented good fits to the experimental results obtained for dune bed conditions. Sediment motion over a dune bed may be approximated by a stationary point process in time and space. (Moore-IVI)
W84-02873

SEDIMENT TRANSPORT IN STRATIFIED TURBULENT FLOW,
Southern Illinois Univ. at Carbondale. Dept. of Thermal and Environmental Engineering.
B. A. DeVantier, and B. E. Larock.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1622-1635, December, 1983. 5 Fig, 1 Tab, 13 Ref, 2 Append. NSF grant CME-7914762.

Descriptors: *Sediment flow, *Turbulent flow, *Stratified flow, Density gradients, Mathematical models, Velocity, Open-channel flow, Multidimensional flows.

An accurate description of many environmental and industrial processes depends upon a good prediction of sediment transport behavior in fluids. Often sediment concentration gradients create density gradients in the bulk fluid which give rise to density currents or stratified flow. Since many problems of practical interest can not be represented as unidirectional flows, a transport model which can be applied to multidimensional flow problems is needed. A mathematical model of sediment laden, density affected turbulent flows is presented. The finite element technique is used in conjunction with the Newton iterative method to solve the resulting partial differential equations. The model satisfactorily predicts velocity and concentration profiles for unidirectional open channel flows. Based on its predictive ability for unidirectional flows, the present model would be applicable to multidimensional flows. Because the model does less well at high volume fractions, improved modeling of particle interactions and a modified settling velocity appear to be needed to improve results. Because the correct trends are noted when velocity and concentration equations are decoupled, and because the dispersion mechanism has been tested

by cases which have no convection effects, the extension of the model to more complex flows is warranted. (Moore-IVI)
W84-02876

SEDIMENT TRANSPORT CHARACTERISTICS OF THE DESERT STREAMS IN INDIA,
Central Arid Zone Research Inst., Jodhpur (India). Div. of Basic Resources Studies.
K. D. Sharma, N. S. Vangani, and J. S. Choudhari.
Journal of Hydrology, Vol. 67, No. 1-4, p 261-272, 1984. 7 Fig, 3 Tab, 7 Ref.

Descriptors: *Sediment transport, *Deserts, *Ephemeral streams, Arid lands, Sediment rates, Sediment concentration, Sediment yield, Sedimentary structures, India.

Runoff and sediment data from 33 stream gauging stations in the arid region of India determines the relationships existing between sediment concentration and sediment yield to the runoff discharge in the desert streams. Sediment concentrations varied from 0.2-53.5 g/l on hillslopes to 1-453 g/l in the downstream channels in alluvium tracts. Similarly, suspended-sediment loads of these streams varied from 1.6-445.7 to 0.6-1082.0 t/sq km per event in hilly and alluvium tracts, respectively. Downstream increase in the sediment concentrations is attributed to the cessation of minor flows due to heavy transmission losses in the alluvium, thus leaving large amounts of loose material which is picked up by the subsequent flows of greater magnitude. The highest concentrations are recorded in the initial runoff, followed by a rapid decrease in concentration during the rising and recession flow stages. There is no correlation between observed sediment concentration and runoff rates. These results are tentatively explained by the varying role of splash and flow velocity on sediment detachment and transport processes during the flow events. (Murphy-IVI)
W84-02897

ESTIMATION OF SOIL EROSION IN INDIA,
Central Soil and Water Conservation Research and Training Inst., Dehra Dun (India).
D. V. V. Narayana, and R. Babu.
Journal of Irrigation and Drainage Engineering, Vol. 109, No. 4, p 419-434, December, 1983. 7 Fig, 4 Tab, 29 Ref.

Descriptors: *Soil erosion, *India, Sediment load, Sediment yield, Erosion rates, Model studies.

Soil erosion is a serious problem in India. In the absence of precise estimates of total erosion in the country, this method arrives at a first estimate of soil erosion, sediment loads of rivers and sedimentation in reservoirs. Existing annual soil loss data for 20 different land resource regions of the country, sediment loads of some rivers, and rainfall erosivity for 36 river basins and 17 catchments of major reservoirs are utilized and statistical regression equations predict sediment yield. Using these expressions and corresponding values of area, rainfall, rainfall erosivity and surface runoff, annual values of total sediment loads of streams, sediment deposition in reservoirs, and sediment lost permanently into the sea are estimated. The first approximation of soil erosion is taking place at the rate of 16.35 ton/ha/annum which is more than the permissible value of 4.5-11.2 ton/ha. About 29% of the total eroded soil is lost permanently to the sea. Ten percent of it is deposited in reservoirs. The remaining 61% is dislocated from one place to the other. (Murphy-IVI)
W84-02928

SEDIMENTOLOGICAL STUDIES OF THE 'ILHA DE MARCHANTARIA' IN THE SOLIMOES/AMAZON RIVER NEAR MANAUS,
Institut fuer Meeresgeologie und Biologie, Wilhelmshaven (Germany, F.R.).
G. Irion, J. Adis, W. J. Junk, and F. Wunderlich.
Amazoniana, Vol. 8, No. 1, p 1-18, September, 1983. 15 Fig, 22 Ref.

Descriptors: *Sedimentation, *Amazon River, *Manaus, *Ilha de Marchantaria, Brazil, Islands, Channel bars, Water level fluctuations, River stage, Erosion.

Sedimentological studies on the Ilha de Marchantaria, an island in the Amazon river near Manaus, reveal the existence of four different structural main units. Sandy channel bars were found consisting of giant ripples which constitute deposits for the formation of islands or newly formed areas of the Vazea. Gradual accumulation was seen on the channel bars leading to the formation of point bar ridges which consist chiefly of small-scale ripples. Between point bar ridges of different ages there exist swales. During rising water level the river water flows from the downward side into the swales where finegrained sediments are deposited. Permanent lakes are formed mainly in the center of the islands. During low water periods the lakes may be cut off from the river. During the high water periods when the whole island is flooded by the river, additional sedimentation takes place especially in the upstream are of the island. There is, however, extensive erosion of the banks on the upstream side of the island. By erosion of the upstream end and sedimentation processes on the downstream end the island moves slowly downstream. (Baker-IVI)
W84-02946

2K. Chemical Processes

PLUTONIUM SPECIATION IN WATER FROM MONO LAKE, CALIFORNIA,
Geological Survey, Denver, CO.
J. M. Cleveland, T. F. Rees, and K. L. Nash.
Science, Vol. 222, No. 4630, p 1323-1325, December, 1983. 2 Fig, 1 Tab, 10 Ref.

Descriptors: *Speciation, *Plutonium, *Mono Lake, California, Solubility, Actinides, Radioactive waste disposal, Carbonates, Fluorides, Water chemistry.

This study of the speciation of plutonium in Mono Lake water was part of a comprehensive investigation of transuranium-element chemistry in ground waters of possible relevance to radioactive waste disposal. The solubility of plutonium was enhanced by the presence of large concentrations of indigenous carbonate ions and moderate concentrations of fluoride ions. In spite of the complex chemical composition of this water, only a few ions govern the behavior of plutonium, as demonstrated by the fact that it was possible to duplicate plutonium speciation in a synthetic water containing only the principal components of Mono Lake water. The chemical composition of the Mono Lake water sample with concentration given in mg/liter was: alkalinity (as CaCO3), 26,300; calcium, 12; iron, 1.0; magnesium, 23; manganese, 0.033; potassium, 1,300; sodium, 26,000; strontium, 0.029; silica, 13; chloride, 22,000; fluoride, 48; phosphate, 20; and sulfate, 8,300; with a pH of 10.0. (Baker-IVI)
W84-02513

SPECIATION OF ALUMINUM IN ACIDIC FRESHWATERS,
Quebec Univ., Sainte-Foy.
P. G. C. Campbell, M. Bisson, R. Bougie, A. Tessier, and J.-P. Villeneuve.
Analytical Chemistry, Vol. 55, No. 14, p 2246-2252, 1983. 3 Fig, 6 Tab, 46 Ref. Environment Canada contract KSD-KA313-1-6026.

Descriptors: *Aluminum, *Speciation, Acidic water, Photooxidation, Ultraviolet, Organic matter, Water chemistry.

The determination of the physical speciation of aluminum in water samples by filtration through polycarbonate membranes proved feasible; control experiments revealed neither contamination nor analyte loss. Treatment of sample filtrates with a fractionally loaded Chelex 100 ion-exchange resin (>75% H(+)-form) allows one to distinguish between different forms of aluminum on the basis of their kinetic and thermodynamic properties. Monomeric hydroxo- and fluoroaluminum complexes exchanged readily (>85% after 30 min), as did low molecular weight polynuclear species. Under similar conditions, forms of Al associated with fulvic and humic acids of natural origin exchanged much more slowly (<5% after 30 min, at an Al:dissolved organic carbon atomic ratio of about 1:155). Before photooxidation, the filterable aluminum present in natural waters exhibited intermediate behavior (0-50% exchange after 30 min); after UV irradiation the nonexchangeable Al fraction had practically disappeared (90-96% exchange after 30 min), suggesting that the major portion of the nonexchangeable Al initially present was associated with organic matter. (Author's abstract)
W84-02558

GEOCHEMISTRY OF THE AMAZON; 2. THE INFLUENCE OF GEOLOGY AND WEATHERING ENVIRONMENT ON THE DISSOLVED LOAD,
Massachusetts Inst. of Tech., Cambridge. Dept. of Earth and Planetary Sciences.
R. F. Stallard, and J. M. Edmond.
Journal of Geophysical Research, Vol. 88, No. C14, p 9671-9688, November, 1983. 13 Fig, 6 Tab, 92 Ref.

Descriptors: *Geochemistry, *Amazon Basin, *Weathering, *Dissolved solids, Erosion, Water chemistry, Substrates, Salts, Geology, Cations, Silicates, Evaporites, Rivers.

In the Amazon Basin, substrate lithology and erosional regime (seen in terms of transport-limited and weathering-limited denudation) exert the most fundamental control on the chemistry of surface waters within a catchment. Secondary effects, such as the precipitation of salts within soils and in stream beds, biological uptake and release, and cyclic salt inputs, are more difficult to discern. Samples can be separated into four principal groupings based on relationships between total cation charge (TZ+) and geology. (1) Rivers with 0<TZ+<200 micro eq/l drain the most intensely weathered materials (Upper Tertiary sediments, soils of the Negro Basin, and similarly weathered regions). These rivers show high levels of Fe, Al, H(+), and coloration and are enriched in Si relative to other major species; they exhibit cation ratios similar to those of substrate rocks. (2) Rivers with 200<TZ+<450 micro eq/l drain siliceous terrains. These rivers are also rich in silica relative to other species. Rivers draining weathering-limited siliceous terrains exhibit the highest TZ+, and their cation load is typically preferentially enriched in Na over K and Ca over Mg when compared to the rocks in their catchments. (3) Rivers with 450<TZ+<3000 micro eq/l drain marine sediments or red beds with high cation concentrations (resulting from the presence of carbonates and minor evaporites in the Peruvian Andes and reduced shales and minor carbonates in the Bolivian Andes). These rivers exhibit relatively high levels of Ca, Mg, alkalinity, and SO4 (in rivers draining reduced shales and minor evaporites). (4) Rivers with TZ+>3000 micro eq/l drain massive evaporites. These rivers are rich in Na and Cl. In the third and fourth categories, rivers tend to have 1:1 (equivalent) ratios of Na:Cl and (Ca + Mg):(alkalinity + SO4), caused primarily by the weathering of carbonates and evaporites. (Author's abstract)
W84-02560

SOME ELEMENTS COMPRISING PARTICULATE MATTER DURING SUMMER IN WATERS OF VARIOUS ENVIRONMENTS IN BRITISH COLUMBIA, CANADA,
Tsukuba Univ., Ibaraki (Japan). Inst. of Biological Sciences.
For primary bibliographic entry see Field 5A.
W84-02725

THE STABILIZATION OF 'DISSOLVED' IRON IN FRESHWATERS,
University of East Anglia, Norwich (England). School of Environmental Sciences.
A. J. Cameron, and P. S. Liss.
Water Research, Vol. 18, No. 2, p 179-185, 1984. 3 Tab, 21 Ref.

Descriptors: *Iron, *Colloids, *Dissolved iron, Natural waters, Humic acids, Tannic acids, Surfactants, Silicates, Phosphates, Hydrogen ion concentration, Aggregation.

In many natural waters Fe(III) exists in an apparently 'dissolved' state at concentrations far higher than predicted from straightforward inorganic solution chemistry. Some of the iron may exist as organic complexes, but it seems more likely that most is present as fine colloidal particles which are stabilized against flocculation by adorption of organic and inorganic species from the water. In many studies, 'dissolved' iron is defined as that which is analytically detectable in the filtrate after passage of the water through a membrane having pores of 0.5 millimicron nominal diameter. Laboratory experiments were conducted to see what substances are capable of holding iron at a concentration of about 1 ppm in a 'dissolved' form (i.e. will pass through a 0.45 millimicron pore size filter) in oxygenated water. The reagents capable of doing this include humic and tannic acids, surfactants such as sodium dodecyl sulfate and sodium dodecylbenzene sulfonate, and the inorganic ions silicate and phosphate. The synthetic polymer polyvinylpyrrollidone and the simple ions Cl(-), HCO3(-), SO4(-) and NO3(-) showed no ability to stabilize iron. The efficiency of phosphate at keeping iron in the 'dissolved' state decreased in the presence of cations, particularly divalent ones, but increased with rise in water pH in the range 6-11. It seems unlikely that much of the stabilization observed for any of the reagents tested is due to their forming complexes with the iron. It is more likely that the substances for which positive results were obtained are able to stabilize fine colloidal iron particles and inhibit them from forming larger aggregates. (Moore-IVI)
W84-02747

OBSERVATIONS ON THE CHEMICAL COMPOSITION OF RAIN USING SHORT SAMPLING TIMES DURING A SINGLE EVENT,
Hope Coll., Holland, MI. Dept. of Chemistry.
M. D. Seymour, and T. Stout.
Atmospheric Environment, Vol. 17, No. 8, p 1483-1487, 1983. 1 Fig, 2 Tab, 11 Ref.

Descriptors: *Chemistry of precipitation, *Acid rain, *Rain, *Hydrogen ion concentration, Sampling, Sulfates, Nitrates, Sodium, Potassium, Calcium, Magnesium, Specific conductivity, Particulates, Washout, Michigan.

Studies of changes in the chemical composition of rainfall during a single rainfall event were initiated in the summer of 1979. During that summer, 20 different events were collected and the pH of each sequentially collected sample was measured. The pH of the individual samples varied between 5.8 and 3.6. The most rapid decrease in pH occurred during the early portion of the rainfall event, while only small increases or decreases in the pH occurred during the latter portion of the event. In 1980, sequential samples of rain, each corresponding to 0.23 mm of rainfall, were collected during single precipitation events at a site in western Michigan and analysed for specific conductance, pH, SO4(2-), NO3(-), Na(+), K(+), Ca(2+) and Mg(2+). A rapid decrease in the concentration of all the measured components except H(+) was observed during the initial portion of the event. The H(+) concentration of the rainwater generally increased during the initial portion of the event. This converse relationship between the H(+) concentration and the SO4(2-) and NO(3-) concentrations is attributed to the rapid washout of atmospheric particulates containing basic salts. Depending upon the type and duration of the event, this washout can cause 50% of the total SO4(2-) and NO3(-) deposition to occur during the first 15-20% of the total rainfall. While sampling of this type may not be possible for all studies of precipitation chemistry, further studies using this method may be useful in describing the effect that atmospheric particulates and rainfall amount have on the relationship between the concentrations of SO4(2-) and NO3(-) in rain and the net deposition of H(+) by a single precipitaion event. (Moore-IVI)
W84-02772

KINETIC STUDIES OF RAINDROP CHEMISTRY. I. INORGANIC AND ORGANIC PROCESSES,
California Univ., Berkeley. Dept. of Chemistry.
T. E. Graedel, and K. I. Goldberg.
Journal of Geophysical Research, Vol. 88, No. C15, p 10865-10882, December, 1983. 10 Fig, 6 Tab, 132 Ref.

Descriptors: *Kinetics, *Chemistry of precipitation, Chemical reactions, Rainfall, Precipitation, Model studies, Nitrates, Aldehydes, Ozone, Photolysis, Hydrogen peroxide.

A model has been formulated to represent the chemistry of raindrops, taking into consideration both inorganic and organic processes totaling 94 reactions in 53 species. Three sets of computations were performed for raindrops of different diameters. In the first two, the initial chemistry of the raindrops was set by the cloud chemistry measurements of APEX (Atmospheric Precipitation Experiment) in the northeastern United States. In the simulations the drops were released into tropospheric air charactertistic of either the suburban or urban northeast. In the third set, designed to simulate urban centers on the east coast, raindrops with composition typical of those over the oceans were dropped in urban tropospheric air. Photochemical processes such as the photolysis of hydrogen peroxide to produce hydroxide radicals and the photolysis of nitrate ions to produce ozone, were significant in raindrop chemistry. Organic chemical reactions of interest and importance occur in raindrops, particularly those of small size, with the oxidation of aldehydes to organic acids being the most important. Significant differences in some species concentrations occur at different altitudes during the fall of the raindrop and for drops of different diameters. These differences are related to the scavenging efficiencies and lifetimes of the drops. Given constant initial concentrations of trace species in raindrops, ion concentrations in rainwater increase as the rain rate decreases and in a steady rainfall the concentrations of scavenged ions decrease as the concentrations of the gaseous precursors decrease. Neither effect is large, however. Below-cloud processes probably do not significantly affect the concentration of strong inorganic acids in rain at ground level unless acid concentrations are low in droplets at cloud base. (Baker-IVI)
W84-02824

ESTIMATION OF AQUIFER RECHARGE AND FLOW FROM NATURAL TRITIUM CONTENT OF GROUNDWATER,
Commonwealth Scientific and Industrial Research Organization, Glen Osmond (Australia). Div. of Soils.
J. S. Colville.
Journal of Hydrology, Vol. 67, No. 1-4, p 195-222, 1984. 3 Fig, 2 Tab, 13 Ref.

Descriptors: *Groundwater recharge, *Groundwater movement, *Tritium, Natural recharge, Aquifers, Mathematical models, Model studies, Irrigation effects.

Groundwater usually contains tritium which originally fell in rain and entered the aquifer as recharge. The systematic measurement of this natural tritium content can be used to estimate recharge and water flow in the aquifer. The theoretical calculations require some plausible assumptions to be made about the aquifer. It is necessary to discuss any bias that these can produce. In particular, it is assumed that sampling successfully draws water equally from all aquifer depths and that the effects of finite hydraulic conductivity and hydrodynamic dispersion can be neglected. A comparison of theoretical distributions of the tritium concentration in groundwater shows that any model of an aquifer should include the effects of irrigation with local groundwater as well as the variations in the amount of recharge and its tritium concentration. The additional recharge of fresh rain water and loss of pumped groundwater associated with irrigation could not be estimated adequately. Presumably, if irrigation had been established longer and over more of the region, then the additional recharge could be estimated as well as natural recharge. Dispersion plays a negligible role in the interpretation of these experimental data. The sensitivity of these estimates to some of the specific assumptions about recharge and initial conditions is tested by using synthetic data that were calculated according to modified assumptions. (Murphy-IVI)
W84-02894

NITROGEN AND PHOSPHORUS FLUXES FROM A FLOODED ORGANIC SOIL,
Agricultural Research and Education Center, Sanford, FL.
K. R. Reddy, and P. S. C. Rao.
Soil Science, Vol. 136, No. 5, p 300-307, 1983. 5 Fig, 14 Ref.

Descriptors: *Nitrogen, *Phosphorus, *Fluctuations, *Flooded organic soil, Organic soils, Ammonification, Nitrification, Detritus, Decomposing organic matter, Floodwater.

Florida has approximately 1.5 million hectares of organic soils, which were formed by the accumulation of the decayed remains of sawgrass and related wetland plants over the last 5000 years. Under laboratory conditions the anaerobic soil layer ammonification was functioning at a rate of 0.11 g N/sq m-day, and NH4+ flux from the anaerobic soil layer to the floodwater and to the aerobic soil layer was 0.045 g N/sq m-day. The sequential N processes functioning in a flooded organic soil include: ammonification in the anaerobic soil layer, upward diffusion of NH4+ from the anaerobic soil layer to the floodwater, nitrification in the floodwater, downward diffusion into the anaerobic soil layer and denitrification in the anaerobic soil layer. Losses due to these processes accounted for about 35% of the mineralized NH4+-N in the 21-cm organic soil column. The ammonification and NH4+ diffusion functioning at a slower rate probably are the limiting processes in N loss from a flooded organic soil. The results also showed that the rate of soluble P production in the anaerobic soil layer was 0.016 g P/sq m-day, and the flux of P, as a result of diffusion, was about 0.0098 g P/sq m-day. Major processes functioning in the anaerobic layer were mineralization of organic P, adsorption-desorption of P, and diffusion from underlying sediment to the overlying water. Losses of P due to these processes accounted for about 53% of the solubilized P in the 21-cm organic soil column. (Murphy-IVI)
W84-02908

SEASONAL VARIATION IN THE MAJOR CATION (NA, K, MG, AND CA) CONTENT OF THE WATER OF LAGO CAMALEAO, AN AMAZONIAN FLOODPLAIN-LAKE NEAR MANAUS, BRAZIL,
Max-Planck-Inst. fuer Limnologie zu Ploen (Germany, F.R.).
K. Furch, W. J. Junk, J. Dieterich, and N. Kochert.
Amazoniana, Vol. 8, No. 1, p 75-89, September, 1983. 6 Fig, 28 Ref.

Descriptors: *Seasonal variations, *Cations, *Lago Camaleao, *Brazil, *Floodplain lakes, Potassium, Sodium, Calcium, Magnesium, Amazon River, Electrolytes, Water level, Nutrients.

Changes in the major cation content of the Lago Camaleao, one of the varzea lakes on an island in the Rio Solimoes/Amazonas near Manaus were monitored for one year. Changes in the electrolyte content of the lake water, presented as total major cation content, were extremely great during the period of investigation. November 1980 to November 1981 showed a pronounced annual periodicity. During the low water period the ion concentration reached its maximum, more than 15 times the concentration in the river at the same time. With rising water level, inflow of comparatively electrolyte poor water from the river and simultaneously increasing rainfall diluted the water in the lake. The electrolyte concentration was not uniform throughout the lake. Concentrations rise from the lake entrance to the inner part of the lake, so that the lake sections distant from the river are up to fifteen times as rich in electrolytes as the river

itself. The uptake of large quantities of nutrients from the system for the growth of macrophytic vegetation, the accumulation of nutrients in macrophytes and sediment, and the release of these nutrients during decomposition and resuspension are among the most important factors contributing to the electrolyte budget in the Lago Camaleao. (Baker-IVI)
W84-02547

2L. Estuaries

NUTRIENT DYNAMICS IN SMALL MESOTROPHIC FENS SURROUNDED BY CULTIVATED LAND; I. PRODUCTIVITY AND NUTRIENT UPTAKE BY THE VEGETATION IN RELATION TO THE FLOW OF EUTROPHICATED GROUND WATER,
Utrecht Rijksuniversiteit (Netherlands). Dept. of Plant Ecology.
For primary bibliographic entry see Field 5C.
W84-02496

FACTORS REGULATING ABUNDANCE AND DISTRIBUTION OF THE SHRIMP NEOMYSIS MERCEDIS IN THE SACRAMENTO - SAN JOAQUIN ESTUARY,
California State Dept. of Fish and Game, Sacramento.
A. C. Knutson, Jr., and J. J. Orsi.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 476-485, July, 1983. 7 Fig, 2 Tab, 21 Ref.

Descriptors: *Estuarine environment, *Shrimp, *Salinity, Water circulation, Drought, Saline water intrusion, Copepods, Food, Deltas, Population dynamics, Pumping plants, Environmental effects.

The mysid shrimp Neomysis mercedis is a major prey of striped bass Morone saxatilis in the inland delta and estuary of the Sacramento and San Joaquin rivers, California. Its abundance during 1968-1981 was highest between 1.2 and 4.6% surface salinity. Cross-delta flow of water to large pumping plants and shallow river channels with high current velocities limited the upstream extent of the shrimp. The population shifted spatially in response to salinity changes caused by variations in river outflow. Annual July to October abundance indexes were highest from 1968 to 1975, and lowest during the drought years 1976 and 1977. Regression analysis showed that population size was negatively related to salinity intrusion and positively related to the abundance of the copepod Eurytemore affinis, an important food item of the shrimp. High N. mercedis populations appear dependent an adequate food supply and minimal salinity intrusion into the western delta. (Author's abstract)
W84-02523

PRODUCTION AND POPULATION DYNAMICS OF CAPITELLA CAPITATA,
Southampton Univ. (England). Dept. of Oceanography.
For primary bibliographic entry see Field 5A.
W84-02552

OBSERVATIONS ON THE DISTRIBUTION AND MOVEMENTS OF MACROBRACHIUM OHIONE (SMITH, 1874) IN THE PASCAGOULA RIVER ESTUARY, JACKSON COUNTY, MISSISSIPPI, U.S.A. (DECAPODA, PALAEMONIDAE),
University of Southern Mississippi, Hattiesburg. Dept. of Biology.
G. Anderson.
Crustaceana, Vol. 44, No. 2, p 123-140, 1983. 4 Fig, 5 Tab, 33 Ref. NOAA grant 04-8-Mo1-92.

Descriptors: *Estuarine environment, *Shrimp, *Macrobrachium, Pascagoula River, Jackson County, Mississippi, Population dynamics, Habitats, Salinity.

Sampling stations were located at 47 sites in the lower Pascagoula River, Jackson County, Mississippi. Fourteen collecting trips were made into the study area from June 1978 to April 1979. The findings of the systematic trapping portion of the study indicated that specific conductance was inversely correlated with trapping success. Salinity was also inversely correlated to trap catch. Temperature correlated positively with trapping success, along with distance from the river mouth. Neither water depth nor dissolved oxygen were significantly correlated with trapping success. In each collection the number of females exceeded the number of males. The mark-recapture study indicated that from April to midsummer M. ohione exhibits positive rheokinesis in the Pascagoula River study area. Shrimp may move upstream at an average velocity of at least 0.460 km/day. (Baker-IVI)
W84-02637

FRESHWATER WETLANDS HUMAN-INDUCED CHANGES: INDIRECT EFFECTS MUST ALSO BE CONSIDERED,
Ottawa Univ. (Ontario). Dept. of Biology.
P. A. Keddy.
Environmental Management, Vol. 7, No. 4, p 299-302, 1983. 1 Fig, 20 Ref.

Descriptors: *Wetlands, *Ecosystems, *Environmental effects, Vegetation, Succession, Massachusetts, Rhode Island.

With the rapid disappearance of North American wetlands, there is a great need for long-term data on changes in wetland ecosystems over time. Two recent studies have documented changes in wetland ecosystems in New England by examining changes in wetland vegetation over time. Larson and others (1980, J. Appl. Ecol. 17:667-673) studied changes in freshwater wetland ecosystems on the Massachusetts Coastal Plain over a 20 year period, while Golet and Parkhurst (1981, Environ. Manag. 5:245-251) studied Rhode Island wetlands over a 33 year period. Both documented shifts in vegetation towards shrub and forest dominated wetlands. Both then concluded that natural succession has changed more wetlands than human impact has. The last conclusion does not necessarily follow from the data provided. Indirect human impact (for example, water level changes, eutrophication, sedimentation) must be considered when assessing human impact on wetlands, particularly given that subtle indirect impact affects larger areas than direct impact from drainage and infilling. When discussing indirect effects of human activity, it is important to carefully define which indirect effects are being considered, since there is a continuum ranging from infilling through to alteration of global CO2 levels. Given the complexity of indirect effects, it is unlikely that most can be recognized in the field. This will be particularly true for the more subtle human-induced effects such as atmospheric CO2 or acid rain. (Moore-IVI)
W84-02641

FORECASTING THE IMPACTS OF GLOBAL FORCES ON AMERICA'S WETLANDS,
Fish and Wildlife Service, Washington, DC.
W. R. Mangun, PH.D.
Journal of Environmental Systems, Vol. 13, No. 1, p 69-76, 1983-84. 2 Fig, 11 Ref.

Descriptors: *Wetlands, *Forecasting, *Environmental effects, Policy making, Decision making, Dredging, Landfills, Water pollution effects.

The future of this nation's wetlands is being shaped by forces in action throughout this country and around the world. If government decision makers are to develop policies adequate to protect these environmentally sensitive resources, wetland scientists and policy analysts will have to integrate their skills to develop a forecasting capability which will effectively predict how these forces will affect the future status of wetlands. The world's wetlands are facing threats from industrial and post-industrial stresses associated with a highly urbanized environment. The direct threats come in the form of dredging, filling, and pollution. The shift in population and industry from the northeast and north-central to the southeast and southwest will cause increasing pollution loads which will inhibit the capacity of wetlands to perform their basic functions. A little more than half of the original wetland acreage remains in the United States. The policy makers of today have an enormous responsibility to formulate public policies which attempt to take into consideration the future state of the global environment. Long-range planning can be an effective tool in the protection of wetlands. Typical long-range planning activities would include: monitoring, forecasting, goal setting, analysis, policy generation (with appropriate pre-testing), and implementation. (Moore-IVI)
W84-02682

GEOCHEMISTRY AND BIOLOGICAL AVAILABILITY OF IRON AND TRACE ELEMENTS IN THE UPPER FRASER RIVER ESTUARY,
British Columbia Univ., Vancouver. Dept. of Geological Sciences.
W. K. Fletcher, G. S. Holmes, and A. G. Lewis.
Marine Chemistry, Vol. 12, p 195-217, 1983. 15 Fig, 2 Tab, 58 Ref. NSERC grant G0450.

Descriptors: *Geochemistry, *Iron, *Trace elements, *Estuarine environment, *Upper Fraser River Estuary, British Columbia, Saline water intrusion, Bioassay, Diatoms, Resuspension, Mixing, Particulates, Cobalt, Copper, Manganese, Lead.

Water samples were collected hourly at three depths from two twenty-five hour stations in the Fraser River estuary (British Columbia). Sampling stations were selected to represent both minimal saline intrusion and prominent salt wedge environments. A bioassay using the diatom Thalassiosira pseudonana was run to evaluate biological availability of the dissolved metals. Inter-element ratios indicate that changes in bulk composition of suspended particulates occur throughout the tidal cycle as a result of resuspension and mixing of particulates from different sources. However, Fe:Ti ratios and leachable Fe indicate loss of about 1 wt.% Fe from river-borne particulates mixing with saline waters. This loss from particulates is accompanied by a corresponding increase of 'dissolved' Fe concentrations, from 10 ppb in both fresh waters and the salt water intrusion, to more than 80 ppb in mixed waters of intermediate salinity. Co, Cu, Mn and Pb show similar trends to Fe which are attributed to their association with 'dissolved' Fe colloids. This is consistent with bioassay data which suggests that the biological availability of metals changes abruptly with the change in dissolved Fe concentrations. (Author's abstract)
W84-02691

REQUIREMENTS FOR MODELING TRACE METAL PARTITIONING IN OXIDIZED ESTUARINE SEDIMENTS,
Geological Survey, Menlo Park, CA.
S. N. Luoma, and J. A. Davis.
Marine Chemistry, Vol. 12, p 159-181, 1983. 1 Fig, 4 Tab, 84 Ref.

Descriptors: *Trace metals, *Estuarine environment, *Sediments, Mathematical models, Particulate matter, Oxidation, Sediment-water interface, Partitioning, Calcium, Magnesium, Kinetics.

The fate of particulate-bound metals is of particular importance in estuaries because major biological energy flows involve consumption of detrital particles. The biological impact of particulate-bound metals is strongly influenced by the partitioning of metals among sediment components at the oxidizing sediment-water interface. Adequate methods for directly measuring this partitioning are not available, thus a modeling approach may be most useful. Important requirements for such a model include: (1) determinations of metal binding intensities which are comparable among sediment components important in oxidizing; (2) comparable determinations of the binding capacities of the several forms of each component; (3) operational determinations of the abundance in natural sediments of components of defined binding capacity; (4) assessments of the influence of particle coatings and multicomponent aggregation on the available binding capacity of each substrate; (5) consider-

ation of the effect of Ca and Mg competition on binding to different components; and (6) determinations of the kinetics of metal redistribution among components in oxidized sediments. (Author's abstract)
W84-02692

THE IDENTIFICATION AND EVALUATION OF BENTHIC MACROINVERTEBRATE ASSEMBLAGES IN AN INDUSTRIALISED ESTUARY-SOUTHAMPTON WATER, UK, USING A LONG-TERM, LOW-LEVEL SAMPLING STRATEGY,
Southern Water Authority, Otterbourne (England). Resources Planning Lab.
For primary bibliographic entry see Field 5C.
W84-02694

MESOCOSM EXPERIMENTS TO DETERMINE THE FATE AND PERSISTENCE OF VOLATILE ORGANIC COMPOUNDS IN COASTAL SEAWATER,
Woods Hole Oceanographic Institution, MA. Dept. of Chemistry.
For primary bibliographic entry see Field 5B.
W84-02790

THE YANGTZE RIVER; PAST, PRESENT, AND FUTURE,
Woods Hole Oceanographic Institution, MA. Dept. of Geology and Geophysics.
J. D. Milliman, J.-Y. Chen, Z.-S. Yang, and M. Ren.
Oceanus, Vol. 26, No. 4, p 20-25, Winter 1983/84. 3 Fig.

Descriptors: *Rivers, *Sediment transport, *Estuarine environment, Yangtze River, China, Sediments, Erosion, Soil conservation, Streamflow, Flow pattern.

The Tangtze has its origins in Tibetan plateaus where it flows eastward to the East China Sea. The River discharge gains steadily as it flows downstream and an increasing number of northern and southern tributaries join the river. Just before the Yangtze reaches the East China Sea, it divides into several distributary channels. With spring-tide elevations up to 4 to 5 meters, onshore currents can be as great as 3 knots during flood tide. During the ebb, currents reverse and attain speeds of 5 to 6 knots in an offshore direction. This seesaw pattern of current flow accounts for sediments moving in a start-and-stop pattern. It is estimated that the Yangtze estuary is accumulating about 250 million tons of sediment annually, or about half the sediment carried by the river. While it is doubtful that the Yangtze or Yellow rivers carried as much sediment prior to deforestation and disruption of native vegetation by human activity, they undoubtedly contributed vast quantities of sediment to the ocean throughout the Quaternary period. Undoubtedly with future climate changes the discharge patterns of the river will also change. On shorter time scales, even more significant changes may occur as increased efforts of soil conservation lower the sediment load of the river considerably. (Baker-IVI)
W84-02831

3. WATER SUPPLY AUGMENTATION AND CONSERVATION

3A. Saline Water Conversion

A METHOD BASED ON EQUILIBRIUM THEORY FOR A CORRECT CHOICE OF A CATIONIC RESIN IN SEA WATER SOFTENING,
Aquila Univ. (Italy). Facolta di Ingegneria.
D. Barba, V. Brandani, and P. U. Foscolo.
Desalination, Vol. 48, No. 2, p 133-146, October, 1983. 4 Fig, 3 Tab, 16 Ref.

Descriptors: *Equilibrium theory, *Cationic resin, *Sea water softening, Desalination, Brines, Water softening.

Increase of the performance ratio in evaporative desalination processes is connected with the increase of top brine temperature, i.e. with removal of calcium sulfate from sea water. The softening of sea water by cationic resins and the regeneration of the bed by blowdown from the evaporator is a feasible process. Its economical convenience is dependent on a correct selection of the resin that takes into account both a high selectivity Ca++/Mg++ and a low concentration factor of the blowdown. In fact a high concentration factor is a favorable parameter for the ionic pretreatment but, since it increases the boiling point elevation of the brine, its influence on the evaporation process is negative. For processes at high performance ratios (14-18) a concentration factor ranging from 2 to 4 causes a reduction of logarithmic mean temperature difference of 50-100% and consequently an increase of heat transfer area of 50-100%. A general criterion based on equilibrium theory useful for a correct selection of the resin to be coupled with evaporative process is shown here. The method, that requires only few experimental determinations, has been utilized to compare various commercial resins tested in the laboratory that do not appear completely satisfactory. A sample of a family of 'tailor-made' resins, modified according to the indications derived from the method, is then presented. (Author's abstract)
W84-02929

3B. Water Yield Improvement

ECONOMIC EVALUATION OF WATER HARVESTING IN MICROCATCHMENTS,
Ben-Gurion Univ. of the Negev, Sde Boker (Israel). Jacob Blaustein Inst. for Desert Research.
G. Oron, J. Ben-Asher, A. Issar, and T. M. Boers.
Water Resources Research, Vol. 19, No. 5, p 1099-1105, October, 1983. 7 Fig, 3 Tab, 7 Ref.

Descriptors: *Microcatchments, *Water harvesting, *Cost-benefit analysis, *Nuts, Arid regions, Almonds, Infiltration basins, Economic aspects, Israel.

A microcatchment is a defined area of a few hundred square meters which is used as a water harvesting element for a single tree. Each microcatchment consists of a contributing area and an infiltration basin in which the tree grows. A cost-benefit analysis of the microcatchment water harvesting (MCWH) technique was carried out for for the Wadi Mashash area (Israel) for almond growing. In highly dry zones (i.e., annual precipitation of less than 150 mm), the predicted income is negative. The introduction of modified technology improved water harvesting and thus increased the predicted net income, but these modifications are associated with additional expenses, leaving the additional benefit questionable. A cost-benefit analysis of MCWH with inserts (perforated vertical drainage pipes) to improve water use efficiency indicates that net income is higher than that of MCWH without inserts. In a highly dry zone the net income is still negative (although only slightly), while in dry zones (i.e., annual precipitation of 250 mm) it becomes positive. Another potential route to make the MCWH system more profitable is to use other plant species. One promising possibility is to plant pistachio trees, which survive with limited amounts of water, and which have a larger return than almonds. (Moore-IVI)
W84-02755

STEADY INTERFACE UPCONING BENEATH A COASTAL INFILTRATION GALLERY,
Asian Inst. of Tech., Bangkok (Thailand). Div. of Water Resources Engineering.
A. Das Gupta.
Ground Water, Vol. 21, No. 4, p 465-474, July-August, 1983. 11 Fig, 1 Tab, 23 Ref.

Descriptors: *Coastal aquifers, *Interfaces, *Upconing, Saline-freshwater interfaces, Infiltration, Infiltration gallery, Water supply development, Groundwater withdrawals, Wells.

The problem of steady upconing of an interface in an unconfined coastal aquifer due to water withdrawal by an infiltration gallery has been analyzed numerically considering different operating conditions of the gallery within the flow domain. The numerical solution procedure is based on the variational formulation of the problem and profiles of the free surface and interface along with the length of the outflow face and the quantity of fresh-water flow to the sea are obtained as solutions to the problem. The analysis leads to a set of dimensionless plots which can be used for planning a suitable water withdrawal scheme for different aquifer geometries with isotropic or anisotropic distribution of hydraulic conductivity, assuring the availability of fresh water without any salt contamination. The effect of upconing of the interface on lowering the water table head at the upstream boundary is negligible for the higher domain length-head ratio. It may be possible to approximate an array of wells which is more likely to be installed in many cases of practical interest by an equivalent continuous gallery if the wells are very close, and if well characteristics and discharges are the same. (Baker-IVI)
W84-02807

3C. Use Of Water Of Impaired Quality

WASTEWATER REUSE IN MUSLIM COUNTRIES: AN ISLAMIC PERSPECTIVE,
University of Petroleum and Minerals, Dhahran (Saudi Arabia). Dept. of Civil Engineering.
For primary bibliographic entry see Field 5D.
W84-02640

CONTRACTUAL REQUIREMENTS TO IMPLEMENT WATER RECLAMATION,
Montgomery (James M.), Inc., Pasadena, CA.
For primary bibliographic entry see Field 6F.
W84-02666

BACTERIOLOGICAL, VIROLOGICAL AND CHEMICAL EVALUATION OF A WASTEWATER-AQUACULTURE SYSTEM,
Murray State Univ., KY. Dept. of Biological Sciences.
For primary bibliographic entry see Field 5D.
W84-02719

EVALUATION OF IRRIGATION WATER QUALITY FOR A SPATIALLY VARIABLE FIELD,
Volcani Inst. of Agricultural Research, Bet-Dagan (Israel). Inst. of Soil and Water.
E. Bresler, D. Yaron, and A. Segev.
Water Resources Research, Vol. 19, No. 6, p 1613-1621, December, 1983. 6 Tab, 21 Ref.

Descriptors: *Irrigation water, *Saline water, *Citrus, Soil water, Solute transport, Salt accumulation, Leaching, Root zone, Saline soils, Crop yield, Income, Water costs.

A model to predict the optimal salt concentration of irrigation water when various sources of water are available is described and illustrated for citrus. The model employs a stochastic model for soil water and solute movement and a linear programming economic model for best solutions over an extended time period. The model was developed for a Mediterranean-type climate where an irrigation (salt accumulation) season is followed by a rainfall (salt leaching) period. Soil water flow generated by an irrigation or rainfall is assumed to be steady and vertical. Transient solute transport is assumed to obey the diffusion-convection equation. The probability of any given average root zone salinity after any cycle of irrigation or rain is calculated for any combination of applied water salinity and initial soil salinity using a probability density function for the saturated hydraulic conductivity. The expectation of the total income from a crop yield having a known response function to soil salinity is maximized by the model subject to a given probability of the average root

zone salinity exceeding a prespecified critical concentration. The cost of water is assumed to decrease as the salinity of irrigation water increases. Optimal water management depending on the salt concentration of the irrigation water over 6 years for citrus is illustrated in terms of minimum cost, maximum income, optimum salt concentration of the irrigation water, spatial distribution of average root zone salinity, and the probability of exceeding a prescribed critical soil salinity concentration. (Author's abstract)
W84-02859

3D. Conservation In Domestic and Municipal Use

SIGNIFICANCE OF LOSSES IN WATER DISTRIBUTION SYSTEMS IN INDIA,
National Environmental Engineering Research Inst., Nagpur (India). Environmental Engineering Consultancy Div.
For primary bibliographic entry see Field 5F.
W84-02801

3F. Conservation In Agriculture

REUSE OF WARM WATER ON PAPER MACHINE PAYS OFF AT MADISON,
Jordan (Edward C.) Co., Inc., Portland, ME.
For primary bibliographic entry see Field 5D.
W84-02512

CULTIVATION AND EVAPORATIVITY EFFECTS ON THE DRYING PATTERNS OF SANDY LOAM SOIL,
Punjab Agricultural Univ., Ludhiana (India). Dept. of Soils.
K. S. Gill, and S. S. Prihar.
Soil Science, Vol. 135, No. 6, p 367-376, June, 1983. 8 Fig, 1 Tab, 15 Ref.

Descriptors: *Cultivation, *Evaporation, *Soil water, Drying, Water conservation, Water loss, Evaporativity.

Laboratory and field experiments were conducted to study the influence of the depth of cultivation on: the loss of water from and below the disturbed layer; the cumulative evaporation (CE) and time (t) relationship; and the advance of isohydric fronts into soil, under various evaporativity (Eo) conditions. Cylinders were filled with air-dry (theta = 1 + or - 0.25 g/100 g) sandy loam soil to a bulk density of 1.5 g/cu cm. The columns were wetted from the top with 19 cm of water, allowed to equilibrate for a week, cultivated to depths of 0.6, and 12 cm, and then subjected to drying under evaporativities of 16 (high), 8 (medium), and 4 (low) mm/day. Drying was studied in field plots cultivated to 0, 5, 10, and 15 cm depths when Eo ranged from 1.8 to 4.3 mm/day (average 2.8 mm/day). Cultivation reduced evaporation under all the Eos, with the highest reduction under the low Eo. The maximum evaporation reduction was obtained after 29 days under high Eo and after 55 days under medium and low Eos. The differences in water loss between the 6- and 12-cm cultivation depths were greater under higher Eo. The relationship CE = Kt0.5 gave an excellent fit for both the 6- and 12-cm cultivation treatments under all Eos. The regression coefficient K increased linearly with Eo, and at a given Eo was lower for 12-cm than for 6-cm cultivation. The cultivated layers dried more rapidly than the corresponding depths of uncultivated soil, but the layers below the loosened soil always had more water in cultivated than in uncultivated and in 12-cm than in 6-cm cultivation. The magnitude of differences in soil water across the junction of cultivated layers and the undisturbed soil below was influenced both by cultivation depth and Eo. The position of 0.18 and 0.15 cu cm/cu cm isohydric fronts was always deeper in uncultivated than in cultivated soil, except within the loosened zone. Cultivation after wetting reduces evaporation losses. Much higher soil water content just below the interface with cultivation than in the corresponding depths without cultivation offer potentialities of carrying over soil water in the seed zone during rainless periods. This is possible through shallow cultivation with depth less than the planting depth to conserve water in the seed zone. (Moore-IVI)
W84-02516

INFLUENCE OF CONSERVATION TILLAGE ON SOIL PROPERTIES,
Kentucky Agricultural Experiment Station, Lexington. Dept. of Agronomy.
R. L. Blevins, M. S. Smith, G. W. Thomas, and W. W. Frye.
Journal of Soil and Water Conservation, Vol. 38, No. 3, p 301-305, May-June, 1983. 3 Fig, 5 Tab, 18 Ref.

Descriptors: *Soil water, *Tillage, *Water conservation, Magnesium, Calcium, Nutrients, Nitrogen, Soil permeability, Moisture loss, Moisture stress, Permeability coefficient.

In a long term tillage study, higher soil moisture under no-till crop production was observed as compared with that under conventional tillage throughout the growing season. Under no-till significantly less evaporation occurred in the growing season. This conservation of soil water may carry the no-till crop through short drought periods without severe moisture stress becoming evident in the plants. Under conditions of excess soil water, however, the extra water conserved under no-till can be detrimental and contribute to denitrification losses. There was no problem with soil compaction in no-tillage soils. Better water movement was noted in no-tillage compared with conventional tillage plots as determined by saturated hydraulic conductivity measurements. No deterioration of soil physical properties was noted after 10 years of continuous no-till corn production. Rapid acidification of the soil surface when high nitrogen fertilizer rates were used was the most obvious chemical change. Increased levels of exchangeable aluminum and manganese were associated with reduced soil pH. Exchangeable calcium was significantly lower for no-till at depths and all nitrogen fertilizer rates compared with conventional tillage. Potassium was concentrated in the 0- to 5-centimeter soil layer under no-till and decreased with depth. Exchangeable magnesium in the 0- to 5-cm soil depths declined with increasing nitrogen fertilizer and was lower in no-till soil depth compared with conventional tillage. Organic matter was twice as high in the 0-5 cm soil depth compared to conventional tillage. This modified soil environment affects chemical reactions and the distribution and activity of microbes. (Baker-IVI)
W84-02561

AQUACULTURE STRATEGIES IN CHINA,
New Alchemy Inst., East Falmouth, MA.
R. D. Zweig.
Oceanus, Vol. 26, No. 4, p 33-39, Winter 1983/84. 13 Fig.

Descriptors: *Aquaculture, *China, Yangtze River, Pearl River, Fish farming, Animal wastes, Wastewater, Water reuse, Nutrients.

In parts of China with sufficient freshwater supplies, particularly in the lower reaches of the Pearl and Yangtze river basins, integrated fish farming plays a predominant role in optimizing space and nutrient utilization. Roughly 60% of freshwater fisheries output comes from the Yangtze River Basin with 30% from the Pearl River area. The total freshwater fish production is 10% of the world's output, or a million metric tons a year, half of which is derived from aquaculture. Aquaculture practices in China date back at least 3,000 years. Because of the wide variety of niches in ponds currently being exploited, a broad range of nutrient resources that otherwise have little direct food value to humans can be put into the ponds and used efficiently. Integrated fish farming in China uses fish polyculture in ponds as its predominant activity. Two main fish culture strategies are used: stocking and harvesting in rotation, and multigrade conveyor culture. The combination of fish culture with animal husbandry and agriculture on integrated fish farms increases efficiency through ingenious use of beneficial nutrient subcycles within the farm itself. Some integrated fish farms also produce silk as mulberry plants are grown adjacent to ponds or directly on their dikes. The silkworm feces as well as cocoon-processing wastewater are used as fertilizer for the ponds. (Baker-IVI)
W84-02832

4. WATER QUANTITY MANAGEMENT AND CONTROL

4A. Control Of Water On The Surface

EFFECT OF THE AQUATIC HERBICIDE ENDOTHAL ON THE CRITICAL THERMAL MAXIMUM OF RED SHINER, NOTROPIS LUTRENSIS,
North Texas State Univ., Denton. Dept. of Biological Sciences.
For primary bibliographic entry see Field 5C.
W84-02536

OPERATION OF A PUMPED-STORAGE STATION DURING PASSAGE OF A FLOOD THROUGH THE DAM OF THE LOWER STORAGE RESERVOIR,
A. D. Gulevich.
Hydrotechnical Construction, Vol. 17, No. 5, p 250-252, May, 1983. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 5, p 34-35, May, 1983.

Descriptors: *Reservoirs, *Flood control, Floods, Pumped storage, Rivers, Water level, Discharge capacity, Discharge measurement.

The operating conditions of the pumped storage station (PSS) are examined under conditions of an insufficient discharge capacity of the spillway. With the use as the lower reservoir of the PSS of the already existing reservoir of the HES with a turbine discharge Qt and spillway calculated for passage of the maximum river discharge Qf.max-Qt, that is without consideration of the redistribution of the flood discharge, the following operating conditions of the PSS can occur. During discharge of the flood discharge Qf < Qt, the PSS will operate mainly with closed spillway outlets and, consequently, without any restrictions on the operation of the PSS and without a substantial effect of its operation on the river regime below the dam. Under conditions of Qt < Qf < Qf.max-Qo.max (maximum additional discharge), the PSS can operate without restricting its capacity, but there will occur a redistribution of the flood runoff of the river being passed into the lower pool during the day and an increase of the daily variations of the water levels in the river below the dam. For optimal use of the capacity of the PSS and HES it is necessary to coordinate control of the gates of the spillway outlets with the operating regime of the PSS. Under the condition of Qf.max-Qo.max < Qf < Qf.max, the PSS can operate in a turbine regime only with a substantial restriction of the time of its operation and capacity. (Baker-IVI)
W84-02656

SURVIVING THE JOHNSTOWN, PA., FLOOD,
Laurel Management Co., Johnstown, PA.
M. Rosenthal.
Journal of the American Water Works Association, Vol. 75, No. 8, p 390-393, August, 1983. 4 Fig.

Descriptors: *Flood control, *Planning, *Johnstown, *Pennsylvania, *Water supply, Federal jurisdiction, Cost analysis, Power, Management, Floods.

In 1977 a devastating flood in Johnstown, Pa created havoc with the city's water system. Recommendations have been made which should enable a water utility to respond more quickly to the need of supplying safe, potable water in such emergencies. Of the 22,500 households served by the water

authority, 55% are supplied from a gravity system fed by five impounded reservoirs. The remaining half of the customers are served through six separate and totally independent pumping systems. The operating center of this widespread and complex system was flooded by the morning of July 20, when 12 inches of water fell in a 7-8 hr period. To restore temporary service to some totally destroyed areas required more than four weeks. Restoration of service was drastically slowed by the loss of two of five sources of supply. The Laurel Run dam had broken and the supply line of the Saltlick reservoir was washed out in several locations. It is urged that a water utility have on hand an inventory of all other water sources available to the community and data on the quantity, quality and location of each. Alternative sources for industrial and fire-fighting purposes should be identified. Plans should be developed for monitoring water supplies, treatment supplies, and equipment against chemical and biological contaminants. A plan should be formulated to assign major repairs, rebuilding or new construction to certain firms or individuals. A substitute source of power should be identified. A good relationship with federal and state representatives as well as with disaster coordinators enables the utility to obtain assistance promptly. (Baker-IVI)
W84-02667

EFFECTS OF PLEASURE-BOAT TRAFFIC ON MACROPHYTE GROWTH IN CANALS,
Liverpool Univ. (England). Dept. of Botany.
K. J. Murphy, and J. W. Eaton.
Journal of Applied Ecology, Vol. 20, No. 3, p 713-729, December, 1983. 5 Fig, 3 Tab, 63 Ref.

Descriptors: *Boating, *Aquatic plants, *Recreation, *Canals, Turbidity, Aquatic weeds, Aquatic weed control, Canal management, Macrophytes, Plant populations.

The waterways under the control of the British Waterways Board are mostly small, artificial channels, 8-16 m wide and less than 3 m deep. They are divided into Cruising canals for boating, fishing and recreation, and Remainder canals of which many are unnavigable but others have been restored for pleasure-boat navigation. Quantitative surveys of plant growth in British Cruising and Remainder Canals show significant associations between community composition, abundance of aquatic macrophytes and pleasure-boat traffic. Cluster analysis revealed four principal groupings of sites, which had significantly different mean boat traffic densities and markedly different macrophyte community compositions and abundances. Maximum-likelihood and regression analysis indicated significant inverse relationships between total, emergent and submerged macrophyte community abundance and boat traffic. Evidence was found for a 'critical' traffic range, about 2000-4000 movements/ha/m depth/year (my), reducing submerged macrophyte standing crop, perhaps by maintaining high daytime water turbidity, during the summer months as there were significant associations between boat traffic density, water turbidity and summer submerged crop. The seasonal distribution of pleasure-boat traffic appeared to be an important influence on submerged macrophyte community abundance. The course of macrophyte community development may be largely determined by the stage in the growth season at which traffic in the range 300-600 movements/ha/m depth/(4 weeks) is attained. Relationships between the abundance of emergent plants and boat traffic were weaker, and there was no significant association with water turbidity. In 1977 approximately 50% of the canal system carried low pleasure-boat traffic density (<2000 my), 24% had traffic within the critical range (2000-4000 my), and 26% had heavy traffic (>4000 my). Canals with no, or very low, boat traffic suffer growths of macrophytes sufficient to impair navigation, angling and water flow. Traffic in the range 100-200 my seems to create a satisfactory balance between ecological and other features of canals. The boats then suppress macrophyte abundance sufficiently to arrest vegetation encroachment, usually without unduly damaging plant community diversity. (Moore-IVI)
W84-02680

THE ECONOMICS OF IRRIGATION WITH NONUNIFORM INFILTRATION,
California Univ., Riverside. Dept. of Soil and Environmental Sciences.
E. Feinerman, J. Letey, and H. J. Vaux, Jr.
Water Resources Research, Vol. 19, No. 6, p 1410-1414, December, 1983. 6 Fig, 14 Ref. California Water Resource Control Board contract 2-043-300-0.

Descriptors: *Infiltration, *Irrigation water, *Economic aspects, Crop yield, Water costs, Hydrologic models, Crop yield, Water use.

Economic implications of nonuniform water infiltration in irrigated fields can be assessed with a simplified hydrologic balance model linked to an economic optimization model through a crop water production function. The effects of nonuniformity are derived by using two production functions that differ in terms of the sensitivity of yield to applications of water greater than that needed to achieve maximum yield. Where crop yield is sensitive to excess water, productivity and optimal levels of water application are lower in nonuniform fields than in uniform fields. If crop yield is not sensitive to excess water, outcomes depend on the price of water relative to crop income net of water costs. The conclusions, then, depend crucially on the form of the production function. An example is used to demonstrate that irrigation technology and management that increases the uniformity of infiltration may increase both productivity and the levels of agricultural water use. (Author's abstract)
W84-02844

REAL-TIME FORECASTING AND DAILY OPERATION OF A MULTIRESERVOIR SYSTEM DURING FLOODS BY LINEAR QUADRATIC GAUSSIAN CONTROL,
Iowa Univ., Iowa City. Inst. of Hydraulic Research.
S. A. Wasimi, and P. K. Kitanidis.
Water Resources Research, Vol. 19, No. 6, p 1511-1522, December, 1983. 11 Fig, 1 Tab, 55 Ref. DOI grants A-077-IA and A-0380IA, NSF grant CEE-8212066.

Descriptors: *Reservoir operation, *Multireservoir networks, *Floods, Flood damage, Mathematical models, Flood forecasting, River forecasting, Storm runoff, Flood routing.

The problem of short-term (daily) operation of a multireservoir system during floods is examined. The problem is how to use all available real-time information to solve the 'tactical' problem of regulating reservoirs to minimize the expected value of flood damage during a relatively short operating horizon and to do so consistently with the long-term operating strategy. A state-space mathematical model is presented for short-term forecasting of river flows and description of the dynamics of a multireservoir system. The model includes reduced-order state-space unit hydrographs to forecast storm runoff from effective rainfall and state-space representations of linear flood routing. The optimization problem is solved in the framework of discrete-time linear quadratic Gaussian (LQG) control. LQG control is a computationally efficient and flexible method of solving the large-dimensional optimization problems associated with the solution of the tactical problem of short-term operation of reservoirs. For application of the LQG control methodology the system must be represented in state-space form with quadratic cost functions subject to linear equality constraints given by the state transition equations. The scheme was found to be suitable for operation under moderate flood conditions when capacity constraints are not likely to become binding. The methodology has been applied and tested in a real-world case. (Author's abstract)
W84-02853

A KINEMATIC MODEL FOR SURFACE IRRIGATION: VERIFICATION BY EXPERIMENTAL DATA,
Louisiana State Univ., Baton Rouge. Dept. of Civil Engineering.
V. P. Singh, and R. S. Ram.
Water Resources Research, Vol. 19, No. 6, p 1599-1612, December, 1983. 14 Fig, 7 Tab, 36 Ref. NSF project NSF-ENG-79-23345.

Descriptors: *Kinematic models, *Surface irrigation, Water surface profile, Recession times, Advance times, Mathematical models.

A kinematic model for surface irrigation is verified by experimental data obtained for 31 borders. These borders are of varied characteristics. Calculated values of advance times, water surface profiles when water reaches the end of the border, and recession times are compared with their observations. The prediction error in most cases remains below 20% for the advance time and below 15% for the recession time. The water surface profiles computed by the model agree with observed profiles reasonably well. For the data analyzed here the kinematic wave model is found to be sufficiently accurate for modeling the entire irrigation cycle except for the vertical recession. (Author's abstract)
W84-02858

RELIABILITY CONSTRAINED RESERVOIR CONTROL PROBLEMS; 2. RANDOMIZED STRATEGIES,
National Research Inst. for Mathematical Sciences, Pretoria (South Africa).
M. Sniedovich, and P. A. Nielsen.
Water Resources Research, Vol. 19, No. 6, p 1622-1626, December, 1983. 1 Fig, 11 Ref.

Descriptors: *Reservoir operation, *Randomized strategies, Reservoir releases, Stochastic process, Heuristic methods.

The structure of release strategies is an important element in the analysis and optimization of reservoir control problems, particularly in stochastic problems. Despite the clear advantages that randomized strategies offer over pure strategies in reliability-constrained reservoir control problems, their use appears limited if one adopts a purely frequency-based approach to probability. This observation is valid for both versions of mixed strategies, although mixing in advance seems to be, at least superficially, more difficult to implement. From the mathematical point of view, mixed strategies can be instrumental in providing upper bounds for heuristic methods designed to generate pure strategies. It is essential to specify which type of randomized strategy is being considered, and to ensure that the solution procedure used does yield randomized strategies for the type specified. Even if they are not actually implemented, the construction of randomized strategies can play an important role in the process of developing good heuristic pure strategies. It does not appear likely that water resources planners will accept these types of strategies because of the frequency-based approach to probability which is commonly used to interpret probabilistic constructs in the water resources context. (Moore-IVI)
W84-02860

INFLOW STOCHASTIC MODELS FOR THE MANAGEMENT OF RESERVOIR SECONDARY YIELDS,
Naples Univ. (Italy). Ist. Elettrotechnico.
G. Ambrosino, G. Fronza, and F. Garofalo.
Journal of Hydrology, Vol. 67, No. 1-4, p 77-95, 1984. 9 Fig, 2 Tab, 7 Ref, 2 Append.

Descriptors: *Reservoir operation, *Firm yield, *Secondary yield, Stochastic methods, Mathematical models, Computer models, Simulation, Lake Maggiore, Italy.

Firm yield from a reservoir can be defined as the flow-rate guaranteed to downstream users, with a given probability. In addition to such requirements there are often secondary needs, which are satisfied or not according to the decision-maker's subjective judgement in the various hydrologic situations. A rather general approach is presented for optimizing the release of these secondary yields, while keeping the primary deficits (deficits corresponding to releases less than firm yield) at their

minimum possible value. This is accomplished by an optimization model (mathematical program), minimizing the overall primary deficit. The program has multiple optimal solutions, among which one is chosen by another mathematical program, maximizing the overall secondary benefit. This final 'solution' of the two mathematical programs is derived explicitly in the form of an optimal time varying operating rule. Since the actual implementation of the rule would require knowledge of all future inflows at each time step, a heuristic modification is introduced. At each time step, future is divided into two parts: next future, which is taken into account by introducing a forecast of its inflows into the procedure, and far, unpredictable future, which is taken into account by a severe 'safety constraint' on its primary deficits. By computer simulation, the management procedure was applied to the hydrologic and water requirement data from Lake Maggiore, in the north of Italy. The simulation of the management procedure was carried out for the period 1947-1966. (Moore-IVI)
W84-02887

RESERVOIR OPERATION: CHOICE OF OBJECTIVE FUNCTIONS,
California Univ., Davis. Dept. of Land, Air and Water Resources.
B. Mohammadi, and M. A. Marino.
Journal of Water Resources Planning and Management, Vol. 110, No. 1, p 15-24, January, 1984. 4 Fig, 5 Tab, 13 Ref. CSRS project CA-D*-LAW-4116-H.

Descriptors: *Reservoir operation, *Objective function, Algorithms, Computers, Computer programs, Computer models, Water management, Optimization, Mathematical models, Multiobjective planning, Multipurpose reservoirs.

An efficient algorithm for the real-time monthly operation of a multipurpose reservoir is a combination of linear programming (used for month-by-month optimization) and dynamic programming (used for annual optimization). Parametric linear programming, minimum required beginning-of-month storages, and an iterative solution procedure result in low computer time and computer storage requirements. Low computer storage requirements allow the model to be run on minicomputers. The model is general enough to be applied to any multipurpose reservoir, such as, water and energy maximization, water and energy maximization with flood control considerations, and water and energy maximization for peak demand months are considered. Thus, the model provides the reservoir operator with different choices for annual optimization. The model is applied to Folsom reservoir of the California Central Valley Project. (Murphy-IVI)
W84-02918

AGRICULTURAL WATER RESOURCES MANAGEMENT IN INDIA,
CH2M Hill, Inc., Gainesville, FL.
U. P. Singh.
Journal of Water Resources Planning and Management, Vol. 110, No. 1, p 30-38, January, 1984. 2 Fig, 12 Ref.

Descriptors: *Agricultural hydrology, *Water management, *India, Irrigation, Irrigation effects, Water table rise, Drainage, Soil conservation.

Agriculture still forms the backbone of India's economy, accounting for almost half of the national income and providing employment to about two-thirds of the work force. Accordingly, the greatest use of water resources has been for agricultural development, which would have benefited considerably by improvements in the management of water resources. Some of the challenges in agricultural development are delivery of water for irrigation, rising water tables, water-logging and severely impeded drainage, increasing soil salinity, soil conservation practices, traditional irrigation practices, size of land holdings, limited research and agricultural extension work, marketing problems and unavailability of modern technology to Indian farmers on economically attractive terms. (Murphy-IVI)
W84-02919

MULTIOBJECTIVE WATER RESOURCES MANAGEMENT PLANNING,
California Univ., Los Angeles. School of Engineering and Applied Science.
P. W. F. Louie, W. W.-G. Yeh, and N.-S. Hsu.
Journal of Water Resources Planning and Management, Vol. 110, No. 1, p 39-56, January, 1984. 8 Fig, 4 Tab, 20 Ref. UCWRC project UCAL-WRC-W-576.

Descriptors: *Multiobjective planning, *Water management, Optimum development plans, Optimization, Water supply, Water supply development, Water quality, Water quality management, Overdraft, Model studies.

A multiobjective optimization procedure using the constraint linear programming technique assists water resource planners to establish a more unified basin-wide management plan which will simultaneously consider the three major aspects in basin-wide planning: (1) water supply allocation; (2) water quality control; and (3) prevention of undesirable overdraft of the ground-water basin. This optimization procedure is designed to be applied in concert with one or more simulation models: a ground-water quantity-and-quality model or a river flow-and-mass transport model, or both, and a model which routes the water from the supply sources to various demand points, through the wastewater collection and treatment facilities, and ultimately to the disposal sites. The influence coefficient method, used as the connecting agent, creates the necessary linkage between the optimization procedure and the simulation models. With this agent, the optimization procedure can be carried out independently of the simulation models, while, at the same time, keeping a good representation of the response surface of the simulation models in the optimization procedure. (Murphy-IVI)
W84-02920

IRRIGATION WATER DELIVERY FOR EQUITY BETWEEN USERS,
Utah State Univ., Logan. Dept. of Agricultural and Irrigation Engineering.
A. A. Bishop, and A. K. Long.
Journal of Irrigation and Drainage Engineering, Vol. 109, No. 4, p 349-356, December, 1983. 1 Fig, 2 Tab.

Descriptors: *Irrigation, *Planning, Decision making, Water management, Water demand, Water supply.

Usually one of three delivery systems is adopted to obtain equity between users: demand, continuous flow, and rotation. The demand method is perhaps the most sophisticated, consisting of making water delivery to the farmer's field upon receiving orders from him specifying the time and amount. The continuous flow method consists of delivering water to each user on a continuous basis. The rotation delivery method is perhaps the most widely used, consisting of providing each user of a common farm ditch the exclusive use of the water for a specified period of time. A procedure for designing a rotating delivery schedule is outlined. To be equitable among users, water deliveries should provide an equal volume of water per unit of land irrigated. The time of day should be alternated so that irrigators share the advantages and disadvantages. The losses of the system including seepage, administration, and time should be apportioned so that no water user has more than his share. (Baker-IVI)
W84-02923

KINEMATIC-WAVE FURROW IRRIGATION MODEL,
Utah State Univ., Logan. Dept. of Agricultural and Irrigation Engineering.
W. R. Walker, and A. S. Humpherys.
Journal of Irrigation and Drainage Engineering, Vol. 109, No. 4, p 377-392, December, 1983. 10 Fig, 2 Tab, 22 Ref. UAES project AES 799.

Descriptors: *Kinematic-wave furrow irrigation model, Model studies, Mathematical models, Surface irrigation, Furrow irrigation, Irrigation efficiency, Surface flow, Flow profiles,.

For a kinematic-wave model of furrow irrigation under both continuous and surged flow management the numerical solution of the differential continuity equation is accomplished with a Eulerian first-order integration coupled with the assumption that flow rate and flow area are uniquely related by the Manning uniform flow equation. Field data from three Colorado sites, a Utah site, and an Idaho site verify the model's continuous flow simulation of advance and recession. The sites represented a wide range of soil types, field slopes and lengths, and duration of the irrigation event. Companion data from the Utah and Idaho sites verified the model's analysis of surge flow conditions. (Murphy-IVI)
W84-02926

MODELING WATER DEMANDS OF IRRIGATION PROJECTS,
Texas Univ. at Austin. Dept. of Civil Engineering.
D. R. Maidment, and P. D. Hutchinson.
Journal of Irrigation and Drainage Engineering, Vol. 109, No. 4, p 405-418, December, 1983. 6 Fig, 1 Tab, 9 Ref.

Descriptors: *Model studies, *Water demand, *Irrigation programs, Irrigation design, Project planning, Agricultural hydrology, New Zealand.

A simulation model for assessing the water demands of large irrigation areas is applied to the mid-Canterbury region of New Zealand. Observations from historical water use patterns provide a basis for demand modeling using simplified irrigation watering, strategies, highlighting climatic time variability as the single most important influencing factor. Per unit area irrigation demands are first estimated for each identified unique combination of soil, crop type and irrigation strategy using daily soil moisture balance simulation over a number of seasons of recorded climate data. These are then combined using crop areas and efficiency weights to give time patterns of areally-aggregated water demand. The model is checked against field trial data, calibrated against water use in an existing irrigation scheme, and applied to demand estimation for a large proposed future project. (Murphy-IVI)
W84-02927

4B. Groundwater Management

DEVELOPMENT OF GROUNDWATER RESOURCES OF SAUDI ARABIA,
University of Petroleum and Minerals, Dhahran (Saudi Arabia). Dept. of Civil Engineering.
I. Ali.
Proceedings of the Institution of Civil Engineers, Vol. 74, Part 1, p 885-898, November, 1983. 2 Fig, 5 Tab, 37 Ref.

Descriptors: *Groundwater resources, *Saudi Arabia, Desalination, Sea water, Artesian springs, Wells, Aquifers, Irrigation, Water supply development, Water reuse.

The Kingdom of Saudi Arabia extends over an area of some 2,177,400 sq km, covering four fifths of the Arabian peninsula. Rainfall in the northern two thirds is scanty, unpredictable and irregular. No rivers or surface waters exist within the kingdom. A number of valleys called wadis, exist which drain the runoff. About 42 dams have been built to increase the groundwater recharge in these wadis. The other major source is sea water with costly desalination. Recycling of sewage is under consideration. The kingdom can be divided into two distinct regions. One third of the total area contains igneous rocks while the remainder consists of sedimentary rocks. Igneous rocks contain little water. Sedimentary rocks contain the aquifers, 11 of which are the main groundwater sources. At present groundwater resources have been and are being investigated, developed, used and managed on the basin concept. During the five years from 1975-1980, 575 wells were drilled and 900 wells are planned for the period 1980-85. The total dissolved solids of groundwater as shown vary greatly from 400 ppm to 36000 ppm. Successful utilization will depend on the purpose for

which the water is used. The use of brackish water for agriculture and drinking within economic limits is a great challenge for the engineers in Saudi Arabia. A large quantity of the groundwater stored in deep aquifers has been estimated to be 25,000 to 30,000 years old and is mainly fossil water with little or no recharge. Care is needed in its use, so as to save it for future generations. (Baker-IVI)
W84-02508

OPTIMAL GROUNDWATER DEPLETION WITH INTERDEPENDENT NONRENEWABLE AND RENEWABLE RESOURCES,
Oklahoma Univ., Norman. Div. of Economics.
M. J. Mueller.
Water Resources Research, Vol. 19, No. 5, p 1091-1098, October 1983. 1 Fig, 20 Ref.

Descriptors: *Water allocation, *Groundwater depletion, *Resource development, Oil industry, Agriculture, Water demand, Optimization, Economic models, Ogallala Aquifer, Costs, Policy making.

An economic model was developed for the optimal use of a nonrenewable resource, groundwater from a nonrecharging aquifer, which is used as an input in the production of a nonrenewable and a renewable resource, petroleum and agricultural crops. The model is based on the Ogallala Aquifer, which has such a small recharge rate that its water can be considered a nonrenewable resource. The two principle activities of the region are agriculture and petroleum production. The problem of optimal use is analyzed using a linear allocation parameter, nonlinear cost functions, and optimal control techniques. The analysis can be useful in policy questions at two levels. First, estimation of the parameters of the total cost functions, plus knowledge of the current rate of production of petroleum and agricultural output, provides the information necessary to determine the value of the allocation parameter. Knowledge of its value would inform policy makers so that they could establish priorities between the two sectors for groundwater use. Alternatively, it would help in establishing and administering regulations so that access to groundwater is not restricted in favor of another sector. (Moore-IVI)
W84-02754

CONJUNCTIVE USE OF GROUNDWATER AND SURFACE WATER FOR IRRIGATED AGRICULTURE: RISK AVERSION,
Geological Survey, Menlo Park, CA. Water Resources Div.
J. D. Bredehoeft, and R. A. Young.
Water Resources Research, Vol. 19, No. 5, p 1111-1121, October, 1983. 16 Fig, 7 Tab, 8 Ref.

Descriptors: *Conjunctive use, *Well capacity, *Irrigation water, *Groundwater pumping capacity, *Economic aspects, South Platte Valley, Colorado, Simulation, Flow augmentation, Water supply development, Low flow.

In the South Platte system in Colorado where surface water and groundwater are used conjunctively for irrigation, the actual installed well capacity is approximately sufficient to irrigate the entire area. This would appear to be an overinvestment in well capacity. The extent to which groundwater is being developed as insurance against periods of low streamflow is examined, using a simulation model which couples the hydrology of a conjunctive stream aquifer system to a behavioral-economic model which incorporates farmer behavior in such a system. The area modeled is patterned after a reach of the South Platte Valley in Colorado. Under current economic conditions the most reasonable groundwater pumping capacity is a total capacity capable of irrigating the available acreage with groundwater. Installing sufficient well capacity to irrigate all available acreage has two benefits: this capacity maximizes the expected net benefits and this capacity also minimizes the variation in annual income - it reduces the variance to essentially zero. The present Colorado plan of 5% flow augmentation may be small in really dry years. An augmentation capacity approaching 10% may be necessary in dry years such as occurred from 1953 to 1956. As pumping capacity is installed in a conjunctive use system, the value of flow forecasts is diminished. Poor forecasts are compensated for by pumping groundwater. It is questionable in systems such as the South Platte with a large installed well capacity for most of the area that one should spend much effort on improving flow forcasts for water supply purposes. (Moore-IVI)
W84-02756

DISTRIBUTED PARAMETER MODELING OF A PRODUCING VAPOR-DOMINATED GEOTHERMAL RESERVOIR: SERRAZZANO, ITALY,
California Univ., Berkeley. Lawrence Berkeley Lab.
K. Pruess, O. Weres, and R. Schroeder.
Water Resources Research, Vol. 19, No. 5, p 1219-1230, October, 1983. 12 Fig, 6 Tab, 25 Ref. DOE contract W-7405-ENG-48.

Descriptors: *Geothermal resources, *Mathematical models, *Serrazzano, *Italy, Geothermal studies, Simulation, Computer models, Steam, Boiling, Pressure, Aquifers, Groundwater recharge, Thermal equilibration, Geohydrology, Injection wells, Condensates.

The simulator SHAFT79 of Lawrence Berkeley Laboratory was applied to a field-wide distributed parameter simulation of the vapor-dominated geothermal reservoir at Serrazzano, Italy. Using a three-dimensional geologically accurate mesh and detailed flow rate data from 19 producing wells, a period of 15.5 years (from 1959 to 1975) was simulated. The reservoir model used is based on field measurements of temperatures and pressures, laboratory data for core samples, and available geological and hydrological information. The main parameters determined (adjusted) during development of the simulation are permeabilities and much of the initial conditions. Simulated patterns of pressure decline show semiquantitative agreement with field observations. Field pressure declined overall somewhat more rapidly than predicted in the simulation. The interface between overlying steam cap and deeper boiling aquifer remains stationary during exploitation and the aquifer boils approximately uniformly throughout in response to production. Some steam flowing to the main well field may originate from deep fractures rather than from boiling in the two-phase zones modeled. Effects of cold recharge, incomplete thermal equilibration between rock and fluid, and different assumptions regarding the depth of the steam/two-phase interface were investigated. Either a diminished volume of the two-phase zone or incomplete thermal equilibration between rock and fluid could very significantly increase the rate of temperature and pressure decline. These two effects could separately or together account for an additional temperature decline of 5-6 C over the simulated period of 15.5 years, which is required to make the simulated average pressure decline agree with the value deduced from field data. The reservoir model is used to extrapolate (forecast) production rates on a well-by-well basis through 1990. Injection of spent condensate is expected to have negligible impact on field performance. (Moore-IVI)
W84-02765

PREDICTION AND ANALYSIS OF A FIELD EXPERIMENT ON A MULTILAYERED AQUIFER THERMAL ENERGY STORAGE SYSTEM WITH STRONG BUOYANCY FLOW,
California Univ., Berkeley. Lawrence Berkeley Lab.
T. A. Buscheck, C. Doughty, and C. F. Tsang.
Water Resources Research, Vol. 19, No. 5, p 1307-1315, October, 1983. 22 Fig, 5 Tab, 18 Ref. DOE contract DE-AC03-76SF00098.

Descriptors: *Thermal energy storage, *Buoyancy flow, *Storage aquifers, *Multilayered aquifers, Water temperature, Mathematical models, Groundwater movement, Mobile, Alabama.

Seasonal aquifer thermal energy storage field experiments were conducted near Mobile, Alabama in 1981-1982. During the first cycle, 25,000 cu m of water at an average temperature of 59 C was injected over a period of 1 mo., stored for 1 mo. and then produced. In the second cycle, a total of 58,000 cu m of water at an average temperature of 82 C was injected over a period of 4.5 mo., then stored for one month and withdrawn. The results of the first two cycles were predicted by numerical modeling before their conclusion with good accuracy. Subsequent comparison of experimental and calculated results provided important insight into areas of model improvement and alternative experimental design. Key factors influencing energy recovery appear to be aquifer heterogeneity (layering) and strong buoyancy flow in the aquifer. Both field temperature measurements and numerical modeling results indicate that hot water movement in this system is strongly influenced by layering and buoyancy flow. Whlie aquifer layering decreases the energy recovery factor by a moderate amount for both cycles, the larger buoyancy flow associated with the high injection temperature of the second cycle is a dominant influence on recovery factor. In general, both are important factors in the estimation of the feasibility of an aquifer thermal energy storage system. An optimization study based on second-cycle conditions calculated a series of scenarios, each using a different injection and production scheme, to study possible ways to improve energy recovery. The results of this optimization study were used in the design of the third-cycle experiment. (Moore-IVI)
W84-02770

USES OF NUMERICAL MODELING IN THE DESIGN AND LICENSING OF DEWATERING AND DEPRESSURIZING SYSTEMS,
Stone and Webster Engineering Corp., Cherry Hill, NJ.
E. S. Bair, and T. P. O'Donnell.
Ground Water, Vol. 21, No. 4, p 411-420, July-August, 1983. 7 Fig, 1 Tab, 11 Ref.

Descriptors: *Dewatering, *Depressurizing, *Construction, *Mathematical models, Hydraulic head, Pumping, Water table aquifers, Simulation, Groundwater movement, Drawdown, Drainage wells, Licenses, Hydraulic gradient.

Numerical models can be used to aid in the design and licensing of dewatering and depressurizing systems by simulating changes in hydraulic head produced by the interference patterns of various configurations and pumping rates of wells, wellpoints, or ejectors. The total quantity of water that must be pumped to achieve the desired objective can be approximated by modeling the inflow rate into a network of constant-head nodes located around the perimeter of an excavation and assigning a hydraulic-head value to these nodes equivalent to the average level to which the water table or potentiometric surface would be lowered by a dewatering or depressurizing system. As a result, it is possible to determine the decrease in the inflow rate as the flow system goes from the period of transient flow, when significant quantities of water are released from storage in unconfined aquifers and hydraulic gradients are steeper, to the period of steady-state flow when no water is released from storage and hydraulic gradients are flatter. Based on the inflow rate data, simulations can be made showing the effectiveness of various pumping well configurations. In these simulations, the number, location, and pumping rates of wells can be varied to design a dewatering or depressurizing system that maximizes well interference and drawdown with a minimum number of wells. Decreases in the inflow rate during transient flow can be accounted for by adjusting well discharge rates during the transient flow period. Simulation results can be used to determine the radius of influence of the system, calculate induced drawdown in nearby wells, determine the amount of time required for predrainage prior to construction, calculate the amount of induced infiltration from nearby surface-water bodies, evaluate the need for contingency wells, and evaluate whether undesirable fluids will be induced to flow toward the excavation. (Author's abstract)
W84-02802

REGIONAL MANAGEMENT OF AN AQUIFER FOR MINING UNDER FUZZY ENVIRONMENTAL OBJECTIVES,
Arizona Univ., Tucson. Dept. of Systems and Industrial Engineering.
I. Bogardi, A. Bardossy, and L. Duckstein.
Water Resources Research, Vol. 19, No. 6, p 1394-1402, December, 1983. 5 Fig, 8 Tab, 39 Ref. NSF grants INT 78-12184 and CEE 8110448.

Descriptors: *Fuzzy set analysis, *Mining, *Aquifer management, Bauxite, Hungary, Dewatering, Grouting, Thermal springs, Mathematical models, Groundwater recharge, Karst hydrology, Costs.

A methodology is developed for the dynamic multiobjective management of a multipurpose regional aquifer. In a case study of bauxite mining in Western Hungary, ore deposits are often under the piezometric level of a karstic aquifer, while this same aquifer also provides recharge flows for thermal springs. N + 1 objectives are to be minimized, the first one being total discounted cost of control by dewatering or grouting; the other N objectives consist of the flow of thermal springs at N control points. However, there is no agreement among experts as to a set of numerical values that would constitute a 'sound environment'; for this reason a fuzzy set analysis is used, and the N environmental objectives are combined into a single fuzzy membership function. The constraints include ore availability, various capacities, and the state transition functions that describes the behavior of both piezometric head and underground flow. The model is linearized and solved as a biobjective dynamic program by using multiobjective compromise programming. A numerical example with N = 2 appears to lead to realistic control policies. Extension of the model to the nonlinear case is discussed. (Author's abstract)
W84-02842

GROUND-WATER MANAGEMENT IN WESTERN KANSAS,
Southwest Kansas Groundwater Management District No. 3, Garden City.
E. D. Jenkins.
Journal of Hydraulic Engineering, Vol. 109, No. 10, p 1314-1322, October, 1983. 3 Fig, 1 Tab, 6 Ref.

Descriptors: *Groundwater management, *Kansas, *Ogallala aquifer, Groundwater depletion, Well spacing, Safe yield, Groundwater mining.

Western Kansas includes an area of 25,000 sq mi and has a semiarid climate. It is underlain by the Ogallala aquifer, which produces water of good quality. Many large-capacity wells have been drilled for irrigation, industrial, and municipal use. Groundwater withdrawals exceed recharge and water levels are declining at an average rate of 3 ft/yr. Water rights in Kansas are considered as property rights and can be bought or transferred to another beneficial use. In 1972, the Kansas Legislature passed the Kansas Groundwater Act authorizing the formation of local groundwater management districts to help control and direct the development and use of groundwater resources. Five groundwater management districts were formed of which the four western districts overlie parts of the Ogallala aquifer. Each district has its own distinct management plan; their ultimate goals are to conserve and prolong the life of the aquifer. Management policies that have the most effect on withdrawals are well spacing and a planned rate of ground-water depletion. The three western districts (1, 3, and 4) have the greatest number of large capacity wells and the highest rate of water level decline, but the least precipitation. Each of these districts has adopted a plan that will allow a portion of the aquifer to be depleted over a period of 20-25 yr. The districts to the east (2 and 5) are not as heavily developed and have more precipitation. These districts have adopted a safe yield management plan. (Moore-IVI)
W84-02866

CONSERVATIVE ESTIMATION OF GROUNDWATER VOLUMES: APPLICATION OF LINEAR PROGRAMMING TO TRITIUM DATA,
Waikato Univ., Hamilton (New Zealand). Dept. of Earth Sciences.
W. E. Bardsley.
Journal of Hydrology, Vol. 67, No. 1-4, p 183-193, 1984. 4 Fig, 3 Ref.

Descriptors: *Groundwater management, *Linear programming, Systems analysis, Decision making, Management, Water resources development, Water management.

Linear programming minimization is a simple conservative course of action when there is insufficient information for direct estimation of the mean transit time (turnover time) by a parametric model. Alternatively, available information may not be in a form suitable for incorporation into a parametric model. For example, if it was felt that something like the classical highly peaked piston-flow model was appropriate, then this could be defined by the single constraint of an upper bound to the mean deviation of exit-age distribution. In this case, the minimum mean transit time and specific exit age distribution near the region of best fit are unlikely to be greatly different from any parametric equivalents. Even so, the linear programming procedure is very much a pragmatic technique, limited to obtaining minimum values of turnover time and groundwater volumes. More detailed aspects of aquifer hydrology are best dealt with in the framework of parametric modelling. (Baker-IVI)
W84-02893

SECONDARY RECOVERY OF WATER,
Texas Tech Univ., Lubbock. Dept. of Civil Engineering.
B. J. Claborn.
Journal of Irrigation and Drainage Engineering, Vol. 109, No. 4, p 357-365, December, 1983. 8 Fig, 7 Ref.

Descriptors: *Secondary water recovery, Injection, Vadose water, Estimated costs, Water level, Interstitial water.

Injection of air into the vadose zone has made water available for recovery by conventional means at two test sites on the High Plains of Texas. The cost of this water, exclusive of research costs, is estimated to be about $50 per acre-ft. Large quantities of water may be available for recovery in aquifers which have experienced long term water level declines, and where a layer of low permeability material is available to prevent rapid escape of the injected air. A possible explanation of the mechanism of removal is that movement occurs because of unbalanced pressure forces on the capillary water. These forces are caused by the flow of the injected air past the pore water. (Murphy-IVI)
W84-02924

4C. Effects On Water Of Man's Non-Water Activities

IRAN'S MODE OF MODERNIZATION: GREENING THE DESERT, DESERTING THE GREENERY,
H. Pazwash.
Civil Engineering, Vol. 53, No. 3, p 48-51, 1983. 2 Fig.

Descriptors: *Aqueducts, *Water conveyance, *Qanats, Iran, Irrigation, Deserts, Arid lands, Water supply development, Groundwater, History.

The history of providing water for irrigation and agricultural purposes in the largely desert country of Iran is considered. Many centuries ago well digging, which had been a primitive means to reach groundwater, was gradually developed into the art of qanat construction. The qanat construction technology is similar to tunneling, but it is more involved and requires a basic understanding of groundwater flow in addition to an accurate surveying and adequate precautions for ventilation and for prevention of collapse in soft soils. Qanats collect fresh groundwater from rich aquifers in mountain slopes, which receive more rain than plains (kavirs) and which absorb a major portion of runoff by infiltration. Through them water is brought from mountain slope aquifers to the center of kavirs, where the groundwater is generally stagnant and often saline. Through construction of qanats, sufficient water was provided to permit adequate irrigation as well as to supply domestic needs in many parts of the Persian plateau. Qanats are also cheaper than wells in providing water to the area in that they do not require the constant upkeep and maintenance which wells often do. Figures indicate that a qanat, on the average, pays off in a period of 30 years, although it gives service for centuries, once it is constructed. Recent changes in Iran through the Land Reform Act have caused the large parcels of land owned by individuals to be divided among many farmers. The upkeep of qanats and conveyance channels was not continued as more and more of the farmers left the farms and headed for the cities. Many farmers drilled new wells where they had previously relied on qanat water. The excessive drawdowns of most of the deep wells rendered many qanats dry and unproductive, causing more farmers to desert their fields. The construction of large dams has also had an impact on the qanat water availability. Poor planning resulted in many errors, leading to the present conditions where about 11% of the available land is in greenery as compared to 28-30% some 20 yeas ago. (Baker-FRC)
W84-02553

NONPOINT WATER QUALITY CONTRIBUTIONS FROM LAND USE,
Arizona Univ., Tucson. School of Renewable Natural Resources.
For primary bibliographic entry see Field 5B.
W84-02683

HYPOTHESIS-TESTING BY MODELLING CATCHMENT RESPONSE,
Hull Univ. (England). Dept. of Geography.
R. C. Ward.
Journal of Hydrology, Vol. 67, No. 1-4, p 281-305, 1984. 9 Fig, 1 Tab, 14 Ref. NERC grants GR3/2543 and GR3/3348.

Descriptors: *Model studies, *Catchment areas, Artificial precipitation, Evapotranspiration, Streamflow, Soil water, Model testing, Computer models.

A hydrologically rigorous process-based catchment model in which the empirical component is minimal consists of precipitation and potential evapotranspiration; output consists of hourly or daily values of actual evapotranspiration, soil-moisture status and streamflow. Detailed comparisons of observed and modelled streamflow and soil-moisture status indicate that in its present preliminary form the model generates hydrologically plausible output data although specific improvements are suggested by an analysis of the major discrepancies between observed and modelled streamflow. (Murphy-IVI)
W84-02899

4D. Watershed Protection

OPTIMAL OPERATION OF MULTIPURPOSE POOL OF ELK CITY LAKE,
Indiana Dept. of Highways, Indianapolis.
S. Esmaeil-Beik, and Y.-S. Yu.
Journal of Water Resources Planning and Management, Vol. 110, No. 1, p 1-14, January, 1984. 6 Fig, 5 Tab, 18 Ref. USDI project B-053-KAN.

Descriptors: *Optimum development plans, *Multipurpose pool, *Elk City Lake, Reservoir Operation, Model studies, Water loss, Stochastic process.

A stochastic dynamic programming develops optimal policies for operating the multipurpose pool of the Elk City Lake in Kansas with serially correlated inflows. The model determines a long-term operating policy to minimize the expected average annual loss. Using the developed optimal policy to

operate the lake from 1967 to 1977 shows a marked reduction in the expected annual losses as compared with the historical operation. (Murphy-IVI)
W84-02917

5. WATER QUALITY MANAGEMENT AND PROTECTION

5A. Identification Of Pollutants

THE INFLUENCE OF THE DISSOLVED OXYGEN CONCENTRATION ON THE PHYSIOLOGY AND ECOLOGY OF SPHAEROTILUS NATANS KUTZ,
Eidgenoessische Materialpruefungs- und Versuchsanstalt, Sankt Gallen (Switzerland).
K. Mechsner.
Oecologia, Vol. 60, No. 1, p 18-20, 1983. 2 Fig, 1 Tab, 17 Ref.

Descriptors: *Dissolved oxygen, *Sphaerotilus, *Metabolism, Bioindicators, Aerobic conditions, Anaerobic conditions, Fermentation.

Sphaerotilus natans, one of the most important indicator organisms for polluted water, assumes a substantial ecological significance by causing a nuisance by its frequent mass development in polluted natural waters and sewage treatment plants. Using a hermetically closed experimental system the influence of continuously decreasing oxygen concentration on the metabolism of S. natans was investigated by concurrently measuring the temperature, pH, oxygen, sucrose, organic acids, diluted organic carbon (DOC) and dry weight. Oxygen and sucrose were eliminated linearly until the detection limit of <0.1 mg O2/l for dissolved oxygen concentration was reached. Under anaerobic conditions neither sucrose, uptake nor organic acid formation occurred and and autolytic processes were evident. The results confirm that Sphaerotilus natans is an aerobic organism with no capacity for fermentative metabolism. (Moore-IVI)
W84-02494

SEDIMENT BIOASSAYS WITH OYSTER LARVAE,
E.V.S. Consultants Ltd., North Vancouver (British Columbia).
P. M. Chapman, and J. D. Morgan.
Bulletin of Environmental Contamination and Toxicology, Vol 31, No. 4, p 438-444, 1983. 1 Tab, 13 Ref.

Descriptors: *Sediments, *Bioassays, *Oysters, *Toxicity, Puget Sound, Washington, Larval growth stages, Development, Mortality.

A simple methodology is presented for undertaking sediment bioassays with oyster larvae, and data are presented to prove the utility of this method. Test sediments were collected from a total of 22 stations in Puget Sound, Washington, generally from areas with high levels of chemical contamination. Control cultures showed extremely low percentages of abnormal larvae (1.1-1.6%). Sediment samples gave dramatic differences in responses ranging from extremely toxic to non-toxic. No live larvae were found after 48 hr in the assay for one station, considered to be the most toxic. Survival values generally agreed with the data on abnormalities. Of the 22 stations tested, 13 were highly toxic to oyster larvae, 5 stations were moderately toxic, and 4 were non-toxic. The development of larval abnormalities in combination with mortality served as an indication of chemical toxicity in tested sedients. The methodology uses higher sediment concentrations than most other studies without problems from physical abrasion, has been shown to work, and provides data comparable to other toxicity tests. (Moore-IVI)
W84-02531

CONFIRMATION OF WATER QUALITY MODELS,
Duke Univ., Durham, NC. School of Forestry and Environmental Studies.
K. H. Reckhow, and S. C. Chapra.
Ecological Modelling, Vol. 20, No. 2/3, p 113-133, November, 1983. 8 Fig, 1 Tab, 52 Ref.

Descriptors: *Water quality, *Model studies, *Simulation, Statistical analysis, Mathematical models.

Water quality simulation models, whether descriptive or predictive, must undergo confirmatory analyses if inferences drawn from the models are to be meaningful. Current practices in the confirmation of simulation models are examined and criticized from this perspective. In particular, labeling this process 'verification' or 'validation' (truth) probably contributes to the often inadequate efforts, since these states are unattainable. The evaluation of scientific hypotheses, or water quality simulation models, may proceed according to inductive logic, the hypothetico-deductive approach, or perhaps according to a falsification criterion. The result of successful testing is at best confirmation or corroboration, which is not truth but rather measured consistency with empirical evidence. Inadequate model confirmation increases the risks associated with the application of the model. Model confirmation costs must be compared with the risk resulting from the use of an unconfirmed model. If confirmation is to be meaningful, rigorous statistical tests must be applied, and calibration-independent data are needed. A number of plausible candidate models (or model sub-routines) should undergo confirmation. Comparison of the performance of the candidates aids the modeler in the determination of the degree of confirmation. (Moore-IVI)
W84-02538

PRODUCTION AND POPULATION DYNAMICS OF CAPITELLA CAPITATA,
Southampton Univ. (England). Dept. of Oceanography.
J. A. Oyenekan.
Archiv fur Hydrobiologie, Vol. 98, No. 1, p 115-126, September, 1983. 7 Fig, 2 Tab, 23 Ref.

Descriptors: *Polychaetes, *Bioindicators, *Capitella, *Population dynamics, *England, Copper, Silt, Hydrocarbons, Reproduction, Larvae, Water pollution effects, Estuarine environment.

A study was made on the production and population dynamics of Capitella capitata occurring in the Southwestern region of Southampton Water, South England. C. capitata was the most abundant polychaete in sediments containing high levels of copper and hydrocarbon. Its abundance was related to silt, copper and hydrocarbon contents of the sediment at two sites near Fawley Esso Petroleum Refinery. Greater densities of C. capitata occurred near the refinery outfalls which contained high levels of sediment copper and hydrocarbon. The C. capitata population in Southhampton Water shows a complex, unsynchronized life cycle with a polytelic pattern of reproduction. Gametes are released throughout the year with peaks in June and December. Benthic larvae resulted from large summer eggs brooded in the parent's tubes but winter larvae failed to settle until spring. Annual production was estimated as 1.6198 and 0.382 g/sq m/yr respectively at the two sites and P:B ratio varied between 3.26 and 11.6. (Moore-IVI)
W84-02552

DETERMINATION OF TOTAL CYANIDE IN THIOCYANATE-CONTAINING WASTEWATERS,
Baker (J.T.) Chemical Co., Phillipsburg, NJ.
N. J. Csikai, and A. J. Barnard, Jr.
Analytical Chemistry, Vol. 55, No. 11, p 1677-1682, September, 1983. 2 Fig, 5 Tab, 27 Ref.

Descriptors: *Cyanide, *Wastewater analysis, *Thiocyanates, Metal cyanides, Nitrates, Oxidants, Interference.

The determination of total cyanide is an important test in assessing wastewaters. The term total cyanide implies the sum of free cyanide present in a sample and produced in a sample treatment that disrupts complex metal cyanides. At high acidities, thiocyanate reacts with nitrate or other oxidants to produce free cyanide. For thiocyanate-containing wastewaters, a total cyanide procedure is reported based on use of EDTA at pH 4.0, acetate buffered, to disrupt the complexes of cadmium, chromium, copper, iron, nickel, and zinc. Nitrite interference is obviated by adding sulfamic acid to the sample. Sulfides are removed from the sample by initial treatment with cadmium carbonate and, if necessary, from distillates with cadmium nitrate. Cyanide can then be determined by either photometry or potentiometry. In evaluating the procedure, both free cyanide and complex metal cyanides were added to both deionized water solutions and wastewater samples containing or spiked with nitrate and thiocyanate. The recovery of cyanide was virtually complete. (Moore-IVI)
W84-02556

DETERMINATION OF ANILINE AND SUBSTITUTED DERIVATIVES IN WASTEWATER BY GAS AND LIQUID CHROMATOGRAPHY,
Battelle Columbus Div., OH.
R. M. Riggin, T. F. Cole, and S. Billets.
Analytical Chemistry, Vol. 55, No. 12, p 1862-1869, 1983. 4 Fig, 5 Tab, 15 Ref. EPA contract 68-03-2952.

Descriptors: *Anilines, *Wastewater analysis, *Gas chromatography, *Liquid chromatography, Industrial wastewater, Effluents.

Gas chromatography (GC) and high performance liquid chromatography (HPLC) methods were evaluated for the determination of anilines in aqueous media. An optimized analytical approach based on GC with thermionic nitrogen-phosphorus selective detection (NPD) is capable of determining a wide variety of anilines at the low part-per-billion level in industrial aqueous discharges, as well as effluents from publicity owned treatment works (POTW). This approach offers better selectivity and sensitivity than HPLC and other GC detectors. A conventional solvent extraction scheme using methylene chloride gave adequate recovery from aqueous waste samples, but cleanup required substantial attention to avoid adsorptive losses. Capillary column chromatography with an SE-54 FSCC offers better sensitivity and selectivity than the optimum packed column. Analytical precision was generally 5-15% RSD and recoveries were generally 75% or better. (Moore-IVI)
W84-02557

MODIFICATION OF THE DETERMINATION OF ORGANIC COMPOUNDS BY HEADSPACE GAS CHROMATOGRAPHY AFTER SORPTION ON SOLID SORBENTS AND LIQUID DESORPTION,
Gdansk Technical Univ. (Poland). Inst. of Inorganic Chemistry and Technology.
A. Przyjazny, W. Janicki, W. Chrzanowski, and R. Staszewski.
Journal of Chromatography, Vol. 262, p 199-209, June, 1983. 3 Fig, 2 Tab, 11 Ref. Polish Academy of Sciences grant MR.I-15.

Descriptors: *Organic compounds, *Gas chromatography, Water analysis, Pollutant identification, Sorption, Desorption, Dimethyl sulfoxide.

The determination of organic pollutants in water and the atmosphere by gas chromatography frequently requires a preconcentration step, usually sorption on solid sorbents, due to their low concentration. A method of determination of organic compounds by headspace gas chromatography after sorption on solid sorbents and liquid desorption has been developed. Water (50%) is added to dimethyl sulfoxide after completion of desorption, which results in an increase of up to two orders of magnitude in the concentration of compounds in the gaseous phase. Owing to its increased sensitivity, the method can be employed for the determination of compounds in the sub-ppb range from small volumes of air or water. An apparatus enables simultaneous analysis of several samples containing compounds with high and low boiling points without the loss of the latter, and multiple extraction of

the sorbent bed. Average recoveries of model compounds are close to 100%, indicating the high accuracy of the method. The calibration curves were linear over the studied range of concentrations. The overall precision, expressed as the relative pooled standard deviation, varied from 2.4% for (CH3)2S to 5.2% for (C2H5)2S2 for samples and from 2.5% for (CH3)2S to 9.1% for (C2H5)2S2 for standards. The detection limit was estimated to be 0.17, 0.77 and 0.76 ppb for (CH3)2S, (CH3)2S2 and (C2H5)2S2, respectively, assuming a 1-cu dm liquid sample. (Moore-IVI)
W84-02559

PHOSPHORUS FLUX RATES IN LAKE SEDIMENTS,
Washington State Water Research Center, Pullman.
S. J. Mawson, H. L. Gibbons, Jr., W. H. Funk, and K. E. Hartz.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1105-1110, August, 1983. 3 Fig, 3 Tab, 23 Ref. EPA contract R805604-01.

Descriptors: *Phosphorus, *Lake sediments, Liberty Lake, Washington, Sediments, Dissolved oxygen, Sediment-water interfaces, Interfaces, Mud-water interfaces.

The release of phosphorus from Liberty Lake sediments was quantified as a function of dissolved oxygen concentrations at the sediment water interface. Liberty Lake sediments range from sand overlying clay at the northwest end to consolidated fibrous plant detrital materials at the south end. A significant release of phosphorus was noted, ranging from a maximum for total phosphorus in the refractory organic silt (ROS) sediments of 127 micrograms/sq m/hr under anaerobic conditions to a minimum of .000979 micrograms/sq m/hr for soluble reactive phosphate (SRP) under aerobic conditions. Maximum release rate observed for heavy organic muck (HOM) sediments was 54.2 micrograms/sq m/hr for total phosphorus under anaerobic conditions. The impact of the release on the phosphorus loading of the lake is a function of the dissolved oxygen concentration at the sediment water interface. The release of soluble reactive phosphate (SRP) is greatest from the HOM sediment, probably due to the greater interstitial phosphate concentrations present in these sediments. (Baker-IVI)
W84-02578

COMPREHENSIVE PROGRAM FOR SURVEILLANCE OF PACKAGE PLANTS AND STABILIZATION PONDS,
Mid-Ohio Valley Health Dept., Parkersburg, WV.
For primary bibliographic entry see Field 5D.
W84-02582

A MARINE RECREATIONAL WATER QUALITY CRITERION CONSISTENT WITH INDICATOR CONCEPTS AND RISK ANALYSIS,
V. J. Cabelli, A. P. Dufour, L. J. McCabe, and M. A. Levin.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1306-1314, October, 1983. 3 Fig, 4 Tab, 37 Ref.

Descriptors: *Recreation, *Indicator organisms, *Water quality, Risk analysis, Risks, Human diseases, Public health, Fecal coliforms, Coliforms, Microorganisms, Enterococcus, Swimming, Marine environment.

The derivation of guidelines and standards based on acceptable risk for recreational water quality is explained. The two microbial guidelines or standards most commonly used in the U.S. are the total coliform limit of 1000/100 mL of water and the fecal coliform limit of 200/100 mL. The microbial guideline states that fecal coliforms should be used as the indicator organism for evaluating the microbiological suitability of recreational waters. Coliforms were rejected as the indicator of choice for evaluating sanitary conditions because of their variable correlation with fecal contamination. Ideally, recreational water quality indicators are microorganisms or chemicals whose densities or concentrations in the water can be quantitatively related to swimming-associated health hazards. One problem with the existing microbial guidelines for direct contact recreational waters is that they are not amenable to, or developed in the context of, risk analysis. They were derived from a barely detectable health effect rather than from exposure-response data. Therefore they do not allow for deliberate decisions by local, state, or federal officials about incremental decreases in the health risks involved. Rather, decision making is limited to acceptance or rejection of the specific limits. In a three year study of New York City beaches performed to determine which were the best indicators, the superiority of enterococci versus fecal coliforms was seen from the regression lines displayed on graphs of linear relationships between swimming-associated rates for gastrointestinal symptoms and mean enterococcus and fecal coliform densities in the water. Not only is this criterion more reliable because of the greater credibility of the information obtained, but also the consequences of the illness are more amenable to economic analysis. (Baker-IVI)
W84-02600

ONE-YEAR SURVEY OF ATP AND DYNAMIC BEHAVIOR OF AN ACTIVATED SLUDGE TREATMENT PLANT,
Laval Univ., Quebec. Dept. de Genie Chimique.
D. Roy, A. LeDuy, and P. H. Roy.
Journal of the Water Pollution Control Federation, Vol. 55, No. 11, p 1348-1354, November, 1983. 6 Fig, 3 Tab, 13 Ref.

Descriptors: *Activated sludge process, *Adenosine triphosphate, Wastewater treatment, Monitoring, Sludge, Aeration, Suspended solids, Bacteria, Fungus, Aerated lagoons.

Results are reported from a 1-year survey on the adenosine triphosphate (ATP) and dynamic behavior of a full-scale domestic wastewater treatment plant. The data is analyzed to investigate any relationships between ATP or ATP pool and other biomass related variables, operating conditions or BOD reduction. The reproducibility of the survey data was excellent for ATP and mixed liquor volatile suspended solids (MLVSS) concentrations in two aerated basins, operated in parallel. Under transient conditions, a linear relationship was found between mixed liquor suspended solids (MLSS) and MLVSS. Under the same dynamic conditions the measurement of ATP did not estimate MLVSS or other biomass-related variables such as the MLSS and the bacterial count. The excellent correlations under dynamic conditions most frequently observed were between MLVSS and fungal count. The ATP could be a good indicator of perturbations of the viability of the microbial flora in the aerated basins. Concentration and viability of the microbial flora were very sensitive to the recycle-flow rate and the sludge wasting rate. The dynamic behavior of the ATP pool in response to the recycling and wasting disturbances confirmed other conclusions for laboratory-scale activated sludge units. No direct relationship was found between BOD5 removal and bacterial or fungal count. However, poor performance of the aerated basins was observed when microbial counts or ATP concentrations were low. (Baker-IVI)
W84-02601

CHEMICAL COMPOSITION AND POSSIBLE MUTAGENICITY OF MUNICIPAL SLUDGES,
Missouri Univ.-Columbia. Environmental Trace Substances Research Center.
T. E. Clevenger, D. D. Hemphill, K. Roberts, and W. A. Mullins.
Journal of the Water Pollution Control Federation, Vol. 55, No. 12, p 1470-1475, December, 1983. 5 Fig, 7 Tab, 12 Ref.

Descriptors: *Sludges, *Chemical analysis, *Land disposal, Municipal wastes, Metals, Organic compounds, Pesticides, Herbicides, PCB, Boron, Beryllium, Cadmium, Chromium, Copper, Manganese, Magnesium, Nickel, Lead, Zinc, Mercury, Arsenic, Selenium, Iron, Potassium, Sodium, Nitrogen, Phosphorus.

Of 74 wastewater treatment facilities studied, none had sludges with significant levels of the tested toxic organic compounds: PCB, lindane, chlorodane, aldrin, hept epox, DDE, dieldrin, endrin, DDT, or BHC. All sludges had high levels of nutrients and could be a source of excellent fertilizer. Some sludges did have high levels of potentially toxic heavy metals, when tested for calcium, iron, potassium, magnesium, sodium, phosphorus, nitrogen, boron, beryllium, cadmium, chromium, copper, manganese, nickel, lead, zinc, mercury, arsenic, and selenium. The application rate of these sludges will be severely limited due to the presence of these metals, if indeed they can be used at all. The mutagenicity potential of sludges from five facilities was evaluated with the Ames test. The results of these tests were negative indicating no mutagenicity. With but a few exceptions, the sludges from the 74 cities in this study should be acceptable for agricultural land applications if the guidelines established by the State of Missouri are followed. (Baker-IVI)
W84-02606

HEXAVALENT CHROMIUM-RESISTANT BACTERIA ISOLATED FROM RIVER SEDIMENTS,
Ohio State Univ., Columbus. Dept. of Microbiology.
G. W. Luli, J. W. Talnagi, W. R. Strohl, and R. M. Pfister.
Applied and Environmental Microbiology, Vol. 46, No. 4, p 846-854, October, 1983. 6 Tab, 35 Ref.

Descriptors: *Chromium, *Bacteria analysis, *Sediments, *Water pollution effects, Cobalt, Antimony, Zinc, Ottawa River, Water analysis, Industrial wastes, Bacteria, Sediment contamination.

Hexavalent chromium, Cr(VI), is a known carcinogen and mutagen; however, the actual mechanisms of Cr toxicity are unknown. Two approaches were used to isolate Cr(VI)-resistant bacteria from metal-contaminated river sediments. Diluted sediments were plated directly onto a peptone-yeast extract (PYE) medium containing 0 to 100 micro g of Cr(VI)/ml. Approximately 840,000 CFU/g were recovered on 0 micro g of Cr(VI)/ml, whereas 400 CFU/g were recovered on PYE plus 100 micro g of Cr(VI)/ml. Alternatively, continuous culture enrichment techniques were employed using PYE and 100 micro g Cr(VI)/ml input at dilution rates of 0.02 and 0.10/h. After six residence periods, 1,000,000,000 CFU were recovered on PYE agar containing 0 micro g of Cr(VI)/ml and 10,000,000 CFU on PYE agar plus 100 micro g of Cr(VI)/ml. Of 89 isolates obtained by direct plating onto PYE, 47% were resistant to 100 micro g of Cr(VI)/ml, and 20% were resistant to 250 micro g of Cr(VI)/ml. When the same isolates were plated onto PYE containing Cr(III), 88% were resistant to 100 micro g/ml but only 2% were resistant to 250 micro g/ml. Cr, Co, Sb, and Zn were found in significantly higher concentrations at an industry-related contaminated site than at a site 11 km downstream. Total Cr in the sediments at the contaminated site averaged 586 micro g (dry weight)/g, and the downstream site averaged 71 micro g (dry weight)/g. The Cr recovered from acid-digested Ottawa River sediment samples was predominantly hexavalent. Five acid digestion procedures followed by atomic absorption spectroscopy were compared and found to be 30 to 70% efficient for recovery of Cr relative to neutron activation analysis. A population of aerobic, heterotrophic bacteria was recovered from sediments containing elevated levels of Cr. However, there was no apparent difference in the number of bacteria resistant to Cr(VI) at the contaminated site as compared to the downstream site. Recovery of Cr-resistant bacteria from river sediments was improved by using continuous culture enrichment as compared to direct plating. (Author's abstract)
W84-02611

MODIFICATION OF DELAYED-INCUBATION PROCEDURE FOR DETECTION OF FECAL COLIFORMS IN WATER,

New York State Office of Public Health, Albany. Center for Labs. and Research.
M. Chen, and P. J. Hickey.
Applied and Environmental Microbiology, Vol. 46, No. 4, p 889-893, October, 1983. 6 Tab, 11 Ref.

Descriptors: *Coliforms, *Bacterial analysis, *Membrane filters, *Holding media, Fecal coliforms, Delayed incubation, Natural waters, Sublethal injury.

Holding media, including the vitamin-free Casitone holding medium (m-VFC) recommended by Standard Methods for the Examination of Water and Wastewater (American Public Health Association, Inc., Washington, D.C., 1980) for use with the delayed-incubation membrane filter procedure, were compared for their ability to maintain viability of fecal coliforms. Delayed-incubation test methods require the use of a holding medium to stabilize bacteria trapped on the surface of a membrane filter while the filter is transported to the laboratory. The media were tested with 60 to 80 pure cultures of fecal coliforms and a variety of natural water samples containing fecal coliforms. Fecal coliform recovery with m-ST holding medium (containing ethanol, sulfanilamide, and Tris at pH 8.6) was significantly greater than recovery with m-VFC (containing vitamin-free casein hydrolysate, sodium benzoate, sulfanilamide, and ethanol). Recovery with m-VFC, was, in turn, significantly greater than with NSB medium (containing nutrient broth, boric acid, and NaCl as major ingredients). Fecal coliform counts obtained with m-ST by the delayed-incubation membrane filter procedure were higher than counts obtained by the standard immediate incubation. Some of the sublethally injured fecal coliforms in natural water samples may have recovered during the incubation period. m-ST is recommended for use in place of m-VFC for the delayed-incubation membrane filter procedure. An improved delayed-incubation membrane filter procedure will enable health authorities to make more reliable estimates of bacterial contamination in the natural aquatic environment and will aid in the identification of sources of contamination. Such a test may also permit bacteriological testing of recreational and other natural waters in areas where testing was previously not possible. (Moore-IVI)
W84-02612

EVALUATION OF FILTERS FOR RECOVERY OF CAMPYLOBACTER JEJUNI FROM WATER,

Texas Univ. Medical School at Houston.
J. J. Mathewson, B. H. Keswick, and H. L. DuPont.
Applied and Environmental Microbiology, Vol. 46, No. 5, p 985-987, November, 1983. 2 Tab, 7 Ref. PHS grant AI-07128.

Descriptors: *Campylobacter, *Microporous filters, *Bacterial analysis, *Depth filters, Public health, Water analysis.

Campylobacter jejuni has been incriminated in several large waterborne outbreaks, but it has rarely been isolated from water itself. Better methodology is needed for the isolation of C. jejuni from water. Three types of 0.45-micro m microporous filters and three different pore sizes of positively charged depth filters were evaluated for their ability to recover C. jejuni from seeded, sterile tap and surface water. The microporous filters tested were Millipore HA, Gelman GN6, and Zetapor. Three pore sizes of Zeta Plus depth filters (05S, 20S, and 50S) were evaluated by using an adsorption-elution technique. The overall percent recovery in both tap and surface water by microporous filters was: Zetapor, 66%; Millipore HA, 33%; and Gelman GN6, 33%. Adsorption-elution with Zeta Plus 50S allowed 89% recovery of C. jejuni. These data suggest that both the positively charged Zetapor microporous filter and the Zeta Plus 50S depth filter are effective filters for the recovery of C. jejuni from water. (Author's abstract)
W84-02613

MICROPLATE FECAL COLIFORM METHOD TO MONITOR STREAM WATER POLLUTION,

Centre des Sciences de l'Environment, Metz (France).
A. Maul, and J. C. Block.
Applied and Environmental Microbiology, Vol. 46, No. 5, p 1032-1037, November, 1983. 1 Fig, 4 Tab, 29 Ref.

Descriptors: *Coliforms, *Bacterial analysis, *Water pollution, Stream pollution, Moselle River, Fecal coliforms, Water analysis, Most probable number test.

A study has been carried out on the Moselle River by means of a microtechnique based on the most-probable-number method for fecal coliform enumeration. This microtechnique, in which each serial dilution of a sample is inoculated into all 96 wells of a microplate, was compared with the standard membrane filter method. It showed a marked overestimation of about 14% due, probably, to the lack of absolute specificity of the method. The high precision of the microtechnique (13%, in terms of the coefficient of variation for log most probable number) and its relative independence from the influence of bacterial density allowed the use of analysis of variance to investigate the effects of spatial and temporal bacterial heterogeneity on the estimation of coliforms. Variability among replicate samples, subsamples, handling, and analytical errors were considered as the major sources of variation in bacterial titration. Variances associated with individual components of the sampling procedure were isolated, and optimal replications of each step were determined. Temporal variation was shown to be more influential than the other three components (most probable number, subsample, sample to sample), which were approximately equal in effect. However, the incidence of sample-to-sample variability (16%, in terms of the coefficient of variation for log most probable number) caused by spatial heterogeneity of bacterial populations in the Moselle River is shown and emphasized. Consequently, it is recommended that replicate samples be taken on each occasion when conducting a sampling program for a stream pollution survey. (Author's abstract)
W84-02614

EFFECT OF AMBIENT TEMPERATURE STORAGE ON POTABLE WATER COLIFORM POPULATION ESTIMATIONS,

Wisconsin State Lab. of Hygiene, Madison.
J. H. Standridge, and J. J. Delfino.
Applied and Environmental Microbiology, Vol. 46, No. 5, p 1113-1117, November, 1983. 4 Tab, 8 Ref.

Descriptors: *Sample preservation, *Sample storage, *Potable water, *Coliforms, Bacterial analysis, Water analysis, Statistical methods, Wisconsin.

Reducing the length of time between sampling potable water and performing coliform analyses may substantially increase costs for water analysis programs. A protocol was developed which uses statistics and probability theory to develop conclusions for a large group of samples by examining data obtained from a smaller group of samples. The intent of this protocol is to provide a facile means of studying the effects of potable water sample storage without costly replicate testing of thousands of samples. Randomly selected samples (from those routinely collected throughout the State of Wisconsin) were analyzed for total coliforms after being held at room temperature (20 + or - 2 C) for 24 and 48 h. Differences in results for the two holding times were compared with differences predicted by probability calculations. Storage of the potable water for up to 48 h had little effect on the public health significance of most samples containing more than two coliforms per 100 ml. Public health officials can decide whether the advantages of allowing samples to be stored for up to 48 h outweigh the disadvantage of not detecting a very small percentage of samples containing 1 or 2 coliforms per 100 ml for the MF test or 2.2 coliforms per 100 ml for the MPN test. (Moore-IVI)
W84-02616

ORGANIC POLLUTANTS IN MARINE SAMPLES FROM PORTLAND, MAINE,

Texas A and M Univ., College Station. Dept. of Chemistry.
L. E. Ray, H. E. Murray, and C. S. Giam.
Chemosphere, Vol. 12, No. 7/8, p 1031-1038, 1983. 1 Fig, 3 Tab, 28 Ref. NSF grants OCE77-25663 and OCE78-02023.

Descriptors: *Portland, *Maine, *Marine sediments, *Organochlorine compounds, *Phthalates, *Marine pollution, Clams, Neanthes, Harbors, DDT, Polychlorinated biphenyls, Biological magnification, Fore River, Back Cove.

The concentrations of several organochlorine compounds and two phthalates, di(n-butyl) phthalate (DBP) and di(2-ethylhexyl) phthalate (DEHP), were measured in sediment, clams and Neanthes virens obtained from Back Cove and the Fore River, Portland Harbor, Maine. Numerous industrial plants located along the harbor are major potential sources of organic contaminants to the area. The area is also a major oil import center, which increases the problem of pollution. The concentrations in sediment ranked as follows: DEHP >> DBP > PCBs >> sigma DDT > chlordane > pentachorophenol (PCP) > alpha-hexachlorocyclohexane similar to hexachlorobenzene. Except for a reversal of PCP and chlordane, the same order was observed in biota. Adsorption of the pollutants onto sediment seemed to protect the biota since the bioconcentration factors for chlordane, DBP and DEHP were less than one; i.e., concentrations in tissue were lower than those in sediment. For the other five compounds there was a very low level of bioconcentration (1.0 to 150 fold). Although most industrial and petroleum-shipping activity is along the Fore River, the most polluted sediment samples were those obtained from Back Cove. This suggests that the flushing action provided by the Fore River and its tributaries is important, and relatively efficient, in washing the pollutants out before they are adsorbed onto the sediment. (Moore-IVI)
W84-02627

ANALYSIS OF WATER AND SEDIMENT FROM THE NUECES ESTUARY/CORPUS CHRISTI BAY (TEXAS) FOR SELECTED ORGANIC POLLUTANTS,

Texas A and M Univ., College Station. Dept. of Chemistry.
L. E. Ray, H. E. Murray, and C. S. Giam.
Chemosphere, Vol. 12, No. 7/8, p 1039-1045, 1983. 1 Fig, 2 Tab, 21 Ref.

Descriptors: *Estuarine environment, *Organic compounds, *Sediments, *Nueces Estuary, *Corpus Christi Bay, *Texas, *Chlorinated hydrocarbons, Hydrocarbons, pesticides, Phthalate esters, Pentachlorophenol, Polycyclic aromatic hydrocarbons, Water pollution sources.

The concentrations of various organic pollutants (PCBs, phthalate esters (PAEs), hexachlorobenzene (HCB), pentachlorophenol (PCP), polycyclic aromatic hydrocarbons (PAHs), and chlorinated hydrocarbon pesticides (CHPs)) were determined in samples of water and sediment from various sites in the Nueces Estuary, Texas. In sediment, the relative concentrations were sigma PAEs >> PCB > sigma CHPs > PCP > HCB; the relative concentrations in water were sigma PAEs > PCP > PCB > sigma CHPs > HCB. In water, the ranking of concentrations corresponds closely to the water solubilities of the compounds, although the measured values are well below the maximum solubilities of each compound. No single site was highest or lowest in regard to all the pollutants measured. However, the site at the city sewage outfall was the highest in three of the five pollutants in water and four of the five pollutants in sediment. A site near industry was the lowest in regard to three of the five pollutants in water, and the 'clean' site was lowest in regard to four of the five pollutants in sediment. (Moore-IVI)
W84-02628

SNAPPING TURTLES - A BIOLOGICAL SCREEN FOR PCB'S,

State Univ. of New York at Albany. Dept. of Chemistry.
P. G. Olafsson, A. M. Bryan, B. Bush, and W. Stone.
Chemosphere, Vol. 12, No. 11/12, p 1525-1532, 1983. 2 Fig, 2 Tab, 17 Ref.

Descriptors: *Pollutant identification, *Organic compounds, *Turtles, *Polychlorinated biphenyls, Organochlorine compounds, Aroclor, Hudson River, Lake Ontario, Great Lakes, Mirex, DDE.

Two snapping turtles, one male of 16.5 kg from Irondequoit Bay, Lake Ontario and a male 17.8 kg for the Upper Hudson River near Hudson Falls, were examined. These two localities had already been shown to contain organic pollutants. A high level of PCB contamination is known to exist in the upper Hudson River, whereas a lower concentration of PCB with the additional pollutant Mirex was associated with Lake Ontario. A total PCB concentration of 3608 ppm was noted in the fat of the turtle from the upper Hudson River. Mirex was found at the 28 ppm level in the Lake Ontario turtle. These findings indicate that snapping turtles are able to store high concentrations of PCB's in their fat without any apparent detrimental effect. The high biomagnification thus permissible allows a wide gradation between the extremes in pollution levels. Furthermore, it facilitates the detection of extremely toxic substances which may be present only in trace amounts. It may be that snapping turtles provide a valuable addition to the species used for monitoring water quality. (Baker-IVI)
W84-02635

THE FLAME RETARDANT TETRABROMOBISPHENOL-A AND ITS METABOLITE FOUND IN RIVER AND MARINE SEDIMENTS IN JAPAN,
Osaka Prefecture Inst. of Public Health (Japan).
I. Watanabe, T. Kashimoto, and R. Tatsukawa.
Chemosphere, Vol. 12, No. 11/12, p 1533-1539, 1983. 3 Fig, 1 Tab, 7 Ref.

Descriptors: *Tetrabromobisphenol-A, *Flame retardants, *Osaka, *Japan, River sediments, Marine sediments, Metabolism, Sediment contamination.

Tetrabromobisphenol-A (TBBP), used as a flame retardant for epoxy and polyester resins, was detected in river sediments collected in Osaka, Japan, at concentrations ranging from 22 to 140 micro g/kg (ppb), as determined on a dry weight basis. TBBP was also found in marine sediments collected at Osaka Bay, though the TBBP levels of these samples were much lower than those from river sediments. The dimethyl ether derivative of TBBP (TBBP-DM), thought to be a decomposition product from microbial methylation, was found in the river sediments but in none of the marine sediments. TBBP-DM residues were about one-hundredth of the TBBP levels. TBBP was not present in commercial TBBP products. It may be a decomposition product of microbial methylation in the sediments. The sediment pollution by TBBP in the Osaka area is widespread and quite serious, particularly in rivers. (Moore-IVI)
W84-02636

THE ANALYSIS OF ORGANOHALIDES IN WATER - AN EVALUATION UPDATE,
Environmental Protection Agency, Cincinnati, OH. Drinking Water Research Div.
R. C. Dressman, and A. A. Stevens.
Journal of the American Water Works Association, Vol. 75, No. 8, p 431-434, August, 1983. 5 Tab, 6 Ref.

Descriptors: *Water analysis, *Organohalides, Organic compounds, Halides, Halogens, Chlorine, Trihalomethanes, Water quality control.

Data acquired during the routine use of an organic halide analyzer are presented. These data were used for judging the quality of measurements of total, purgeable, and nonpurgeable organic halides as well as judging the instrument's dependability and ease of operation. The repeatability of results obtained during routine analysis was used to set criteria for accepting or rejecting data. Duplicates of samples containing a total organic halide (TOX) concentration of 25 micrograms Cl/liter or less were accepted if within 34% of one another. Duplicates of samples containing more than 25 micrograms of Cl/liter were accepted if within 16% of one another. The method for determining purgeable organic halides (POX) was compared with the purge and trap method for determining total trihalomethanes. A decrease or increase in TOX concentration of the sample during storage can adversely affect the quality of measurements. A two-week holding time was suggested to avoid problems with a decrease in TOX. Sodium sulfite crystals rather than highly unstable sodium sulfite in solution should be used for reducing residual chlorine. (Baker-IVI)
W84-02669

EFFECTS OF HOLDING TIME AND TEMPERATURE ON COLIFORM NUMBERS IN DRINKING WATER,
Environmental Protection Agency, Cincinnati, OH. Environmental Criteria and Assessment Office.
A. E. McDaniels, and R. H. Bordner.
Research and Technology, Vol. 75, No. 9, p 458-463, September, 1983. 5 Fig, 4 Tab, 15 Ref.

Descriptors: *Coliforms, *Drinking water, *Water analysis, Bacteria, Water quality control, Potable water, Sampling.

Samples collected from a municipal distribution system were split, stored at ambient temperature (22 degrees C), and refrigerator temperature (5 degrees C) and analyzed over time for total coliform and heterotrophic bacterial densities. Coliform populations declined significantly at both temperatures after 24 hours. The rate of decline was 2.5 orders of magnitude greater at 22 degrees C than at 5 degrees C. Average losses in 24 hours were 34% at 5 degrees C and 87% at 22 degrees C. Growth and interference of heterotrophic bacteria with coliform colonies on membrane filter plates were frequently observed for samples held at ambient temperature for 30 hours. A model based on actual coliform recovery was developed to predict initial coliform counts in samples held at various times before examination. For the waters examined, samples held at 22 degrees C for 30 hours with initial coliform counts as high as 100/100 mL could have been reported as satisfactory, thus resulting in inaccurate and misleading information. (Baker-IVI)
W84-02670

MICROBIAL ALTERATIONS IN WATER DISTRIBUTION SYSTEMS AND THEIR RELATIONSHIP TO PHYSICAL-CHEMICAL CHARACTERISTICS,
Rensselaer Polytechnic Inst., Troy, NY. Dept. of Chemical and Environmental Engineering.
C. N. Haas, M. A. Meyer, and M. S. Paller.
Journal of the American Water Works Association, Vol. 75, No. 9, p 475-481, September, 1983. 8 Tab, 14 Ref.

Descriptors: *Microorganisms, *Water distribution, Water quality control, Population dynamics, Temperature effects, Acidity, Organic carbon, Organic compounds.

A statistical analysis was performed of microbial and physical chemical data to determine whether variations in microbial dynamics were related to variations in physicochemical variables in water distribution systems. Total organic carbon did not appear to be a significant parameter in controlling microbial populations in water distribution systems. Increasing values of pH, temperature, and turbidity were associated with increasing concentrations of microorganisms in water distribution systems. Although an inverse association exists between chlorine residuals and microbial densities, this association explains only a small proportion of the variance in microbial densities. Thus, this study does not support the hypothesis of a consistent association of major importance between residual chlorine and microbial water quality parameters in distribution systems. Total coliforms can be isolated from water distribution samples for which the physical and chemical water quality is indistinguishable from the water quality of samples that have no coliforms. The use of TOC, turbidity, pH, temperature, and chlorine residual measurements is insufficient to estimate, with a high degree of reliability, either the density or the changes in density of microorganisms in water distribution systems. Incorporation of a time of year variable does little to improve the associations developed. Thus, either additional physical and chemical parameters are important in governing microbial dynamics in water distribution systems or there is a significant random component. In either case, control of one or more of the physical chemical variables measured in this study is insufficient to assure consistent microbial concentrations. (Baker-IVI)
W84-02672

METHODS FOR TESTING THE EFFICACY OF ULTRAVIOLET LIGHT DISINFECTION DEVICES FOR DRINKING WATER,
Health and Welfare Canada, Ottawa (Ontario). Health Protection Branch.
For primary bibliographic entry see Field 5F.
W84-02673

EELGRASS (ZOSTERA MARINA L.) AS AN INDICATOR ORGANISM OF TRACE METALS IN THE LIMFJORD, DENMARK,
Aarhus Univ. (Denmark). Botanical Inst.
H. Brix, J. E. Lyngby, and H. H. Schierup.
Marine Environmental Research, Vol. 8, No. 3, p 165-181, 1983. 6 Fig, 2 Tab, 46 Ref.

Descriptors: *Eelgrass, *Bioindicators, *Trace metals, *Limfjord, *Denmark, Aalborg, Struer, Lead, Copper, Cadmium, Zinc, Interstitial water, Urban areas.

The concentrations of Pb, Cu, Cd and Zn were determined in above- and belowground parts of eelgrass (Zostera marina L.) at forty stations in a shallow, brackish water area (the Limfjord, Denmark). The concentrations of the trace metals were significantly elevated near the cities of Aalborg (Pb, Cu) and Struer (Cd). Trace metals concentrations in above and belowground parts of eelgrass were log-normal distributed and the concentrations of Cd, Cu and Zn in aboveground parts were significantly higher than in belowground parts. Furthermore, a significant correlation between trace metal concentrations in above- and belowground parts was found. The background level of trace metal concentrations in eelgrass in the Limfjord was estimated. The application of eelgrass as a monitoring organism is discussed; it is suggested that the concentration of some trace metals in above- and belowground parts of eelgrass may be used as a measure of the bioavailable fraction of these trace metals in ambient and interstitial water (sediment), respectively. (Author's abstract)
W84-02693

CONCENTRATIONS OF UNSUBSTITUTED POLYNUCLEAR AROMATIC HYDROCARBONS IN BAY MUSSELS (MYTILUS EDULIS) FROM OREGON, USA,
Oregon State Univ., Corvallis. Dept. of General Science.
M. C. Mix, and R. L. Schaffer.
Marine Environmental Research, Vol. 9, No. 4, p 193-209, 1983. 1 Fig, 4 Tab, 30 Ref.

Descriptors: *Mussels, *Hydrocarbons, *Aromatic compounds, *Yaquina Bay, *Oregon, *Polynuclear aromatic hydrocarbons, Carcinogens, Pollutant identification, Liquid chromatography.

Concentrations of fifteen unsubstituted polynuclear aromatic hydrocarbons (PNAH) were measured in Mytilus edulis from two sites in Yaquina Bay, Oregon, during 1979-1980. M. edulis were collected monthly or bimonthly from two separate populations. Mussels from Y1M, an old railroad trestle, supported by weathered pilings, were sampled from January 1979 to June 1980, at which time the site was destroyed during the construction of a marina. The second population, from Y2M, where mussels were removed from wooden pilings and

metal ladders along the Oldtown bayfront, was smaller and sampling was discontinued after April 1980, due to the small number of mussels. The analytical procedure involved the use of high performance liquid chromatography to identify and quantify 15 unsubstituted PNAH including phenanthrene, fluoranthene, pyrene, benzo(c)phenanthrene, triphenylene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,c)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene, indeno(1,2,3-c,d)pyrene and coronene. There were significant differences in PNAH levels between the two populations. The average total concentrations in mussels inhabiting the more industrialized Y2M was 986.2 micro g/kg compared with 273.9 micro g/kg in mussels from the more remote site Y1M across the bay. Substantial differences were found in the concentrations of different PNAH in M. edulis examined during this study. The smaller, more water soluble, compounds were concentrated to one or two orders of magnitude above the larger, less soluble PNAH. Thus, the more toxic 3- and 4-ring PNAH were present in much greater concentrations than the carcinogenic 5- and 6-ring PNAH. (Moore-IVI)
W84-02695

THE USE OF INTERFERENCE SUPPRESSANTS IN THE DIRECT FLAME ATOMIC ABSORPTION DETERMINATION OF METALS IN WATER; SOME PRACTICAL CONSIDERATIONS,

National Inst. for Water Research, Pretoria (South Africa).
R. Smith, E. M. Bezuidenhout, and A. M. van Heerden.
Water Research, Vol. 17, No. 11, p 1483-1489, 1983. 13 Fig, 4 Tab, 5 Ref.

Descriptors: *Interference, *Flame atomic absorption, *Trace metals, Ionization, Cesium, Lanthanum, Chromium, Calcium, Aluminum, Silica, Sulfates, Phosphates, Water analysis.

Standard water analysis methods recommend a variety of different interference suppressants to control chemical and ionization interference effects in the flame atomic absorption determination of certain metals in water. In order to overcome any confusion arising from the difference with regard to the use of interference suppressants, the adoption of a cesium/lanthanum 'universal' suppressant is suggested. In the studies of both the 12.5 g/l lanthanum and the 0.5 g/l cesium : 2 g/l lanthanum solutions proved to be satisfactory suppressants for the determination of calcium in the 10 waters analyzed, as well as for the suppression of up to 200 mg/l phosphate, sulfate and aluminum, and of up to about 25 m/l silica in the determination of 20 mg/l calcium in the synthetic samples. This suppressant is generally equal to or better than the other suppressants for the control of chemical and ionization interferences, and at considerable savings in time, reagents and glassware. (Murphy-IVI)
W84-02698

AN IMPROVED MICRODESULPHONATION/GAS LIQUID CHROMATOGRAPHY PROCEDURE FOR THE DETERMINATION OF LINEAR ALKYLBENZENE SULPHONATES IN U.K. RIVERS,

Unilever Research Port Sunlight Lab. (England).
J. Water, and J. T. Garrigan.
Water Research, Vol. 17, No. 11, p 1549-1562, 1983. 7 Fig, 5 Tab, 19 Ref.

Descriptors: *Water analysis, *Anionic surfactants, *Gas liquid chromatography, *Linear alkylbenzene sulfonates, United Kingdom, River Rhine, Pollutant identification, Methylene blue, Biodegradation.

An improved microdesulfonation/gas liquid chromatography (GLC) procedure is described for the specific determination of microgram/liter levels of linear alkylbenzene sulfonates (LAS) in aqueous environmental samples including sewage, sewage effluent and surface waters. The LAS is concentrated from samples as its methylene blue complex by a large-scale solvent extraction and is then freed from potential interferences by a series of clean-up steps, i.e. ion-exchange chromatography, hydrolysis and solvent extraction, prior to its desulfonation with a concentrated phosphoric acid reagent. The resulting alkylbenzene hydrocarbons are recovered and quantitatively determined by a capillary GLC technique with the aid of internal standards (primary and secondary alkylbenzene sulfonate isomers) added at the initial concentration stage. The introduction of the clean-up stages, particularly a selective extraction of the LAS as the 1-menthylheptyl amine salt into hexane, has resulted in GLC traces that are free from major interferences and in which it is possible to readily identify LAS isomers on the basis of the relative retention times. The procedure has a limit of detection of less than 10 micrograms/l LAS in a sample and allows the quantification of sub-microgram/liter levels of individual isomers (C9-C15 homologues). The mean recovery of a C12 LAS internal standard through the complete procedure is 91% for the environmental samples analysed. This procedure, together with a non-specific methylene blue colorimetric method (for determining anion surface active material), has been used in a monitoring exercise to establish the levels of LAS and methylene blue active substances (MBAS) in U.K. rivers and the River Rhine. A mean MBAS level of 0.15 mg/l was found at the U.K. river sites selected (35 samples), of which only 26% on average was attributable to LAS by microdesulfonation/GLC analysis. However, the levels of LAS and its contribution to the total MBAS in rivers was found to vary with the nature of the sampling location, i.e. depending whether it was above, below or in the vicinity of a sewage effluent discharge. The distribution of the LAS isomers at these sites also showed differences that could be explained in terms of their relative biodegradabilities. (Author's abstract)
W84-02703

MUTAGENICITY AND ORGANIC SOLUTE RECOVERY FROM WATER WITH A HIGH-VOLUME RESIN CONCENTRATOR,

Los Angeles County Sanitation Districts, Whittier, CA.
R. L. Jenkins, C. A. Jacks, R. B. Baird, B. J. Scheybeler, and L. B. Neisess.
Water Research, Vol. 17, No. 11, p 1569-1574, 1983. 2 Fig, 4 Tab, 20 Ref.

Descriptors: *Concentrators, *Mutagens, *Organic compounds, Potable water, Recovery, Resin columns, Wastewater, Water analysis, Wastewater analysis.

This concentrator utilizes low pressure filtration of a water sample followed by high pressure pumping through 45-75 micrometer macroporous ion exchange and nonionic resin columns. Elution and workup yields a concentrate in acetonitrile suitable for chemical analysis and bioassay. The high-volume sampler achieves an average 70% organic removal with four 1150 ml columns, from a 100-200 l wastewater or potable water sample pumped at 200 ml/min and 8000-10,000 kN/sq m. Sample elution yields composite resin concentrates which are mutagenic to Salmonella typhimurium strains TA98 and TA100. No mutagenicity is observed in concentrator effluents or in blanks between samples. The main advantage of the resin concentrator is in savings of time and solvent for a large sample volume. Recoveries of spikes of compounds taken from the EPA priority pollutant list are reported. (Murphy-IVI)
W84-02704

PENTACHLOROPHENOL BIODEGRADATION-I; AEROBIC,

Purdue Univ., Lafayette, IN. Environmental Engineering Lab.
L. P. Moos, E. J. Kirsch, R. F. Wukasch, and C. P. L. Grady, Jr.
Water Research, Vol. 17, No. 11, p 1575-1584, 1983. 9 Fig, 1 Tab, 26 Ref.

Descriptors: *Biodegradation, *Pentachlorophenol, Acclimation, Continuous Stirred Tank reactors, Volatilization, Wastewater, Sorption, Aerobic digestion, Suspended solids.

The biodegradation of pentachlorophenol (PCP) was tested in a three phase protocol. Phase I involved acclimation; phase II allowed determination of biodegradation kinetics through use of continuous stirred tank reactors (CSTR) operated at solids retention times of 3.2, 7.8, 12.8 and 18.3 days; phase III assessed the importance of volatilization and sorption in PCP removal and evaluated the extent of biodegradation. Over the range of stirred tank reactors studied, PCP was found to be biodegradable with first order kinetics; the rate constant had a value of 0.0017 L/micro g/d. The minimum concentration of PCP attainable in a CSTR was found to be 27 micrograms/L. Additional studies suggested that the full relationship between the PCP degradation rate and the PCP concentration followed an inhibition-type function, with the maximum rate occurring at a PCP concentration of around 350 micrograms/L. PCP was mineralized by the culture, with the liberation of CO2 and the incorporation of carbon into cell material. Neither volatilization nor sorption removed significant amounts of PCP from the reactors. (Author's abstract)
W84-02705

STRIPPING ANALYSIS OF ZINC IN NATURAL WATERS UTILIZING THE MEDIUM EXCHANGE METHOD,

New Mexico State Univ., Las Cruces. Dept. of Chemistry
J. Wang, and B. Greene.
Water Research, Vol. 17, No. 11, p 1635-1638, 1983. 4 Fig, 9 Ref.

Descriptors: *Zinc, *Water analysis, *Medium exchange, *Anodic stripping voltammetry, Natural waters, Trace metals, Monitoring.

A simple and sensitive flow system for anodic stripping voltammetry (ASV) with medium exchange, utilizing the thin mercury film electrode and the differential pulse stripping mode is employed for monitoring trace metals in river water. Solution exchange is achieved by simply turning a three-way stopcock placed between the solution reservoirs and the detector. In order to minimize the interference due to the hydrogen evolution current, that masks the zinc peak in analysis of acidified natural waters, more suitable electrolyte is transferred (following the deposition step) into the detector. Measurements can be performed in the presence of oxygen in the sample solution, utilizing an oxygen free exchange solution. The method is sensitive, convenient, and easily adapted for continuous surveillance. (Moore-IVI)
W84-02710

SIMULTANEOUS DETERMINATION OF TOTAL NITROGEN AND TOTAL PHOSPHORUS IN WATER USING PEROXODISULFATE OXIDATION,

Kyoto Prefectural Inst. of Hygienic and Environmental Sciences (Japan).
J. Ebina, T. Tsutsui, and T. Shirai.
Water Research, Vol. 17, No. 12, p 1721-1726, 1983. 8 Fig, 6 Tab, 8 Ref.

Descriptors: *Nitrogen, *Phosphorus, *Water analysis, Nitrates, Orthophosphates, Chemical analysis.

A method by which the total nitrogen (TN) and total phosphorus (TP) in water samples can be determined simultaneously employing peroxodisulfate oxidation was developed. A solution of 0.074 mol/l K2S2O8-0.075 mol/l NaOH was adopted for the oxidizer, which made it possible to carry out alkaline peroxodisulfate oxidation for TN and acid peroxodisulfate oxidation for TP in turn during a single autoclaving. The pH values changed from 12.57 to approximately 2.0 and the period of alkalinity was estimated at 1.42 min at 120 C. The products of oxidation were nitrates and orthophosphates and both were measured simultaneously by an AutoAnalyzer. In order to simplify the procedure as much as possible, test tubes almost as large as the sample cups placed on an AutoAnalyzer sampler were used as the digestion vessels and the contents in them were neutralized in the flow

system. Recoveries were excellent, with higher rates for nitrogen compounds than for the alkaline peroxodisulfate oxidation method. The limits of detection were satisfactory. The method has proven to be both simple and reliable and has made it possible to determine simultaneously and rapidly the TN and TP of large numbers of samples. (Moore-IVI)
W84-02717

ALL-WEATHER TROUGHS FOR PERIPHYTON STUDIES,
National Water Research Inst., Vancouver (British Columbia). Pacific and Yukon Region.
M. L. Bothwell.
Water Research, Vol. 17, No. 12, p 1735-1741, 1983. 6 Fig, 27 Ref.

Descriptors: *Periphyton, *Algae, *Troughs, Water pollution effects, Nutrients, Col weather apparatus, Biomass, Growth, Thompson River, British Columbia.

An on-site, experimental, continuous-flow trough system has been designed for intersite comparisons of periphyton settlement and net growth. The trough apparatus was used successfully in multiple experiments to compare the settlement and net growth of algal periphyton communities in different reaches of the Thompson River, British Columbia, upstream and downstream of point-source discharges of phosphorus. The study required experimental troughs with two unique capabilities; operation under ambient sub-zero temperatures, and determination of passive settlement rates at each site. The apparatus incorporates features that enable trouble-free operation in sub-zero weather. A dark-trough is used to measure passive settlement rates at each site. These values are used to correct light-trough accrual to obtain true net accumulation rates. Such corrections are needed for intersite comparison of periphyton growth rates by the biomass accrual method under conditions of slow algal growth. The low sampling variance, high analytical sensitivity and rapid chlorophyll accumulation characteristics of the troughs, combined with the use of a dark control have permitted the successful measurement and comparison of passive settlement rates of algal periphyton in different reaches of the Thompson River system. (Moore-IVI)
W84-02718

A COMPARISON OF MICROBIAL BIOASSAYS FOR THE DETECTION OF AQUATIC TOXICANTS,
Montana State Univ., Bozeman. Dept. of Microbiology.
G. A. McFeters, P. J. Bond, S. B. Olson, and Y. T. Tchan.
Water Research, Vol. 17, No. 12, p 1757-1762, 1983. 3 Fig, 1 Tab, 25 Ref. EPA grant R80725601.

Descriptors: *Bioassay, *Toxicity, *Bacteria, *Algae, Water pollution, Microorganisms, Fish, Herbicides, Luminescence.

The toxicity of 35 test chemicals was analyzed using two microbial bioassay systems. The commercially available Microtox Toxicity Analyzer System TM and the two-organism procedure of Tchan were used to determine the concentration of test chemicals resulting in a 50% reduction in response (EC50). Both of the tests employed a luminescent bacterium (Photobacterium phosphorium) while the procedure of Tchan also utilized an alga (Dunaliella tertiolecta). Results from the two microbial tests were compared with available data obtained with fish toxicity bioassays and with each other. The Microtox TM procedure was somewhat more sensitive than the Tchan bioassay in detecting most of the test chemicals and fish bioassays were generally more sensitive than either of the microbial tests. As a notable exception, photosynthesis-inhibiting herbicides were detected at remarkably lower concentrations with the procedure of Tchan than any of the other bioassays. The role of microbial bioassays is presently unclear. The greater sensitivity of traditional fish toxicity tests for many compounds must be weighed against the cost and time effectiveness of microbial methods. Greater sensitivity with the microbial tests might be achieved if toxic substances in water are suitable concentrated. (Moore-IVI)
W84-02720

SOME ELEMENTS COMPRISING PARTICULATE MATTER DURING SUMMER IN WATERS OF VARIOUS ENVIRONMENTS IN BRITISH COLUMBIA, CANADA,
Tsukuba Univ., Ibaraki (Japan). Inst. of Biological Sciences.
S. Ishizaka, J. G. Stockner, K. Kobayashi, K. Shima, and K. Katori.
Water Research, Vol. 17, No. 12, p 1815-1821, 1983. 4 Fig, 5 Tab, 25 Ref.

Descriptors: *British Columbia, *Particulate matter, *Trace elements, *Metals, Silicon, Iron, Chlorine, Calcium, Manganese, Zinc, Silicates, Glacial flower, Lakes, Marine environment, X-ray fluorimetry.

Multi-elemental traces comprising particulate matter in natural water collected during summer in 1978 and 1979 from British Columbia, Canada, were analyzed by alpha-particle excited X-ray fluorometry. Common elements from all waters examined were Si, Cl, Ca and Fe. The similarity of their distribution in different aquatic environments was statistically analyzed. They were distributed homogeneously in the marine environment but heterogeneously in the freshwater environments. No heavy metals concerned with the environmental standards were detected for all waters examined. Iron was found as the only common metal in the particulate matter, and the concentrations of iron were generally low. In glacially oligotrophic lakes, the concentration of Fe was highest and in a stagnant deep oligotrophic lake it was the lowest. Mn and Zn were the next most common metals. High concentrations of particulate silica reflect the presence of diatoms or silicoflagellates in oligo or mesotrophic waters and glacial flower containing silicate minerals in glacial lakes. Correlations suggest some inhibitory effects of Si and possibly Fe on the turnover rates of organic matter, i.e. inhibitory effects on the microbial activities responsible for the turnover. Iron increased the turnover rates in the marine environment. (Moore-IVI)
W84-02725

MICRODETERMINATION OF BROMIDE IN WATER BY GAS CHROMATOGRAPHY,
National Inst. of Hygienic Sciences, Tokyo (Japan).
M. Ando, and Y. Sayato.
Water Research, Vol. 17, No. 12, p 1823-1827, 1983. 8 Fig, 3 Tab, 17 Ref.

Descriptors: *Bromide, *Gas chromatography, *Ion-exchange chromatography, Water analysis, Chemical analysis, Interference.

Bromide of ppb levels in water can be accurately determined by ion-exchange chromatograph, potassium permanganate oxidation and head space gas chromatograph (ECD). Bromide reacted with citric acid and potassium permanganate to form pentabromoacetone, which then turned into bromoform. The bromoform was measured by a head space gas chromatograph. The formation of bromoform was interfered with by chloride, humic acid and phenol. The ion-exchange chromatograph (Amberlite CG-400, 10 mm i.d. X 70 mm; elutant 0.1 M sodium nitrate, 70 ml and 0.5 M sodium nitrate, 25 ml) was used to separate bromide from the interfering substances. The minimum detectable limit of bromide is 1 microgram (10 ppb) and the calibration curves maintain a linearity up to 150 micrograms (1.5 ppm). (Moore-IVI)
W84-02726

EXPERIMENTS USING DAPHNIA TO MEASURE LANDFILL LEACHATE TOXICITY,
British Columbia Univ., Vancouver. Dept. of Civil Engineering.
J. W. Atwater, S. Jasper, D. S. Mavinic, and F. A. Koch.
Water Research, Vol. 17, No. 12, p 1855-1861, 1983. 5 Fig, 5 Tab, 12 Ref.

Descriptors: *Landfill leachates, *Toxicity, *Daphnia, *Bioassay, Trout, Salmon, Residual oxygen bioassay, Municipal wastes, Costs.

Leachate from municipal refuse was analysed for acute toxicity using Daphnia pulex, rainbow trout (Salmo gairdneri) and sockeye salmon (Oncorhynchus nerka) as test organisms. Procedures used in conducting the daphnia bioassay are detailed. The 3 1/2 year testing program was designed to compare daphnia bioassays with standard fish bioassays and residual oxygen bioassays (ROB). Toxicity test results using daphnia are a good indicator of municipal landfill leachate toxicity, comparing very favorably to parallel test results obtained using the standard static 96-hr fish bioassay. Daphnia toxicity results obtained did not compare nearly as well with parallel ROB determination. This may be related to problems in the ROB testing. The regression analyses showed that zinc played an extremely important role as a determinant of daphnia toxicity, accounting for over 90% of observed variations. No disadvantages were seen in using daphnia rather than standard fish bioassay procedures. There are distinct advantages in the areas of total cost and test simplicity. (Moore-IVI)
W84-02727

GAS CHROMATOGRAPHY IN WATER ANALYSIS-I; ORGANIC PROFILES OF WATER SOURCES,
National Coal Board, Stoke Orchard (England). Coal Research Establishment.
P. Burchill, A. A. Herod, K. M. Marsh, C. A. Pirt, and E. Pritchard.
Water Research, Vol. 17, No. 12, p 1891-1903, 1983. 9 Fig, 2 Tab, 17 Ref.

Descriptors: *Gas chromatography, *Water analysis, *Organic compounds, Water treatment, Water sources, Potable water.

A method has been developed and used extensively for the routine chromatographic scanning of water sources for trace organic compounds. The method involves solvent extraction of the water with dichloromethane, followed by analysis of the concentrated extract by gas chromatography on a glass SCOT capillary column with flame ionization detection to yield a water profile. Over 600 extracts from rivers, canals, reservoirs and various stage of water treatment, collected between January 1979 and October 1980 as part of a potability study, were examined. The profiles were quantified using n-paraffin standards and a computerized data system. Components were detected at levels as low as 0.01 micro g/l in the water samples. A Kratos MS-30 double-beam mass spectrometer equipped with a DS-50 data system was used in conjunction with gas chromatography to identify types in over 60 of the organic extracts. Components were generally identified at levels as low as 0.1 micro g/l in the water samples. Many components did not give molecular ions and reference spectra were generally unavailable. In such cases, accurate mass measurement using the double-beam technique, which allowed the calculation of atomic compositions for fragment and molecular ions, was particularly valuable. (Author's abstract)
W84-02731

GAS CHROMATOGRAPHY IN WATER ANALYSIS-II; SELECTIVE DETECTION METHODS,
National Coal Board, Stoke Orchard (England). Coal Research Establishment.
P. Burchill, A. A. Herod, K. M. Marsh, and E. Pritchard.
Water Research, Vol. 17, No. 12, p 1905-1916, 1983. 10 Fig, 6 Tab, 24 Ref.

Descriptors: *Gas chromatography, *Haloforms, *Herbicides, *Chlorophosphate esters, Flame photometry, Raw water, Water treatment.

Gas chromatographic methods using selective detectors have been applied successfully to the determination of haloforms, herbicides and chlorophosphate esters in water extracts. Electron capture detection has been used for the determination of the four haloforms, $CHCl_3$, $CHCl_2Br$, $CHClBr_2$

and CHBr3 in pentane extracts. The very low detection limits render both the extracts and calibration solutions highly susceptible to contamination, and precautions necessary for their handling and storage are described. Mass spectrometric single ion monitoring of gas chromatographic effluents has been used for the determination of the herbicides MCPA, MCPB and Mecoprop in methylated ether extracts. Possible interference from other components of the water extracts is discussed, and it is concluded that more than one ion should be monitored for each herbicide to minimize the interference. A flame photometric method involving detection at 528 nm has been developed for the determination of chlorophosphate esters in dichloromethane extracts. The method is extremely specific for phosphorus compounds, but some interference from sulfur compounds may be observed. This can be minimized by the use of high efficiency capillary columns. Detection limits and linear response ranges for the methods are given, and detector selectivities are discussed. Typical chromatograms are shown, and representative results for raw and treated waters are also given. (Author's abstract)
W84-02732

A COMPARATIVE STUDY OF THE CONCENTRATION OF POLYNUCLEAR AROMATIC HYDROCARBONS BY OPEN CELL POLYURETHANE FOAMS,
National Water Research Inst., Burlington (Ontario).
B. K. Afghan, R. J. Wilkinson, A. Chow, T. W. Findley, and H. D. Gesser.
Water Research, Vol. 18, No. 2, p 9-16, 1984. 1 Fig, 6 Tab, 31 Ref.

Descriptors: *Polynuclear aromatic hydrocarbons, *Water analysis, Aromatic compounds, Hydrocarbons, Extraction, Costs.

The concentration of dissolved polynuclear aromatic hydrocarbons (PAH) using open cell polyurethane foams is described. Parameters affecting the concentration of PAH have been optimized including the types of polyurethane foams, flow rates, volume of sample, eluting solvents, etc. It is possible to extract PAH at parts per trillion (pg ml/l) levels in natural waters and the method can be modified to analyze dissolved PAH from environmental samples. Significant amounts of PAH were retained by particulate matter in the samples and were not extracted by polyurethane foam or other solid extractants. The use of polyurethane foam provides advantages over other solid absorbents particularly when large samples are analyzed on a routine basis by offering high flow rates, good capacities and low costs and over solvent extraction for the same reasons as well as being insoluble, easily separable and non-polluting. Since very little weight of polyurethane is needed, the material cost is very low and the extracted samples can be easily transported. (Moore-IVI)
W84-02736

A MODIFICATION OF THE TRENT INDEX FOR USE IN DENMARK,
Copenhagen Univ., Hilleroed (Denmark). Det Ferskvands-Biologiske Lab.
M. M. Andersen, F. F. Riget, and H. Sparholt.
Water Research, Vol. 18, No. 2, p 145-151, 1984. 9 Fig, 2 Tab, 30 Ref.

Descriptors: *Denmark, *Invertebrates, *Pollution index, Water pollution, Stream pollution, Asellus, Chironomus, Bioindicators, Europe.

The central part of Jutland, which is cultivated alluvial lowland, was chosen for the study. The sites which were investigated covered a broad spectrum of running water types in Denmark. All together, 149 samples of macroinvertebrates were collected on 4 occasions during the span of one year. The samples were collected at 72 sites in 25 streams distributed within 17 watersheds. Based on the macroinvertebrates, a new pollution index has been devised which can be used as a surveillance system in Danish streams. The index is inspired by the Trent Index although it was necessary to incorporate two new principles: Asellus aquaticus and Chironomus sp. are used as negative taxa, with a negative influence on the index value; and the taxonomic groups have been replaced by establishing positive and negative index groups, where the number of negative index groups is subtracted from the number of positive. Thus, the utility of the basic principle, increasing pollution affecting decreasing numbers of taxonomic groups, is enhanced. The index was designed for Denmark, but the streams in Holland and the lowland of Germany and England are quite similar to those in Denmark; the index may therefore be applicable to the whole North European lowland. (Moore-IVI)
W84-02744

A PROCEDURE FOR ENRICHING AND CLEANING UP RHODAMINE B AND RHODAMINE WT IN NATURAL WATERS, USING A SEP-PAK C18 CARTRIDGE,
Nederlands Inst. voor Onderzoek der Zee, Texel.
R. W. P. M. Laane, M. W. Manuels, and W. Staal.
Water Research, Vol. 18, No. 2, p 163-165, 1984. 3 Tab, 11 Ref.

Descriptors: *Rhodamine B, *Rhodamine WT, *Tracers, *Adsorption, Dyes, Dye releases.

An enrichment and clean-up procedure is described for Rhodamine B and Rhodamine WT in natural waters. Sep-pak C18 cartridges were used to adsorb the Rhodamine dyes from aqueous solutions. Complete desorption of Rhodamine B and Rhodamine WT on the Sep-pak was achieved. The concentration of the dyes could be increased more than a 100-fold. The concentration of Rhodamine B in the North Sea during a tracer experiment was measured using three different methods. The Sep-pak procedure gave lower concentrations of Rhodamine B than the direct fluorometric measurements. It is concluded that when the Sep-pak procedure is used to enrich Rhodamine dyes there is no interference from salts, pH, pigments and natural fluorescence on the dye fluorescence. This enrichment and clean-up procedure has advantages in tracer experiments. With the same amount of dye it is possible to measure for a longer period. For short experiments, less dye needs to be used. (Author's abstract)
W84-02745

DETERMINATION OF CATIONIC SURFACTANTS IN WASTE- AND RIVER WATERS,
Procter and Gamble Co., Cincinnati, OH. Ivorydale Technical Center.
V. T. Wee.
Water Research, Vol. 18, No. 2, p 223-225, 1984. 1 Fig, 3 Tab, 6 Ref.

Descriptors: *Surfactants, *Water analysis, *Wastewater analysis, *Liquid chromatography, Colorimetry, Thin-layer chromatography, Quarternary ammonium compounds.

Three analytical methods were used to determine the concentration of ditallow dimethyl ammonium chloride (DTDMAC), a cationic surfactant in river water, sewage influent and sewage effluent. The methods consist of: high performance liquid chromatography (HPLC) coupled with conductimetric detection; a colorimetric procedure commonly referred to as disulfine blue active substance (DBAS); and a combination of DBAS and thin-layer chromatography (TLC). The DBAS was less specific and sensitive than either DBAS-TLC or HPLC and therefore tended to overestimate the concentration of DTDMAC in environmental samples. DBAS-TLC and HPLC are comparable in specificity although HPLC is more sensitive and requires significantly less time to perform than either DBAS or DBAS-TLC. The overall advantages of the HPLC procedure make it an attractive analytical technique to accurately measure the concentration of DTDMAC in the environment. The HPLC method can conveniently provide a very good estimate of the contribution of high molecular weight quarternary ammonium compounds in environmental matrices. This accurate estimate will be useful in evaluating the environmental impact of quarternary ammonium compounds. (Moore-IVI)
W84-02749

CULTURED RAINBOW TROUT AND HUMAN CELLS EXPOSED TO PCBS IN THE EVALUATION OF CYTOTOXICITY OF AQUATIC POLLUTANTS,
Quebec Univ., Montreal. Dept. de Chemie.
F. Denizeau, and M. Marion.
Water Research, Vol. 18, No. 2, p 247-251, 1984. 2 Fig, 19 Ref.

Descriptors: *Toxicity, *Trout, *Polychlorinated biphenyls, *Bioassay, Water pollutants, Cell culture, Protein, DNA, RNA, Growth.

A class of pollutants which represents a considerable threat to the aquatic and ultimately human life includes compounds of low acute toxicity, low water solubility or high lipid affinity and high bioaccumulation capacity. As part of program aimed at developing a bioassay system capable of detecting the toxicity of water contaminants including those of low water solubility and low acute toxicity, rainbow trout gonad cells (RTG-2) and human skin epithelial cells (NCTC 2544) were selected for testing material. RTG-2 and NCTC 2544 cells were exposed to Aroclor 1254 at 100 ppb and 1 ppm for a complete cell growth cycle. The following parameters were measured as indicators of toxic effects: total protein, DNA and RNA content; the incorporation of tritiated thymidine in DNA and C-14 uridine in RNA. The trout cells showed a greater sensitivity to Aroclor 1254 than did the human cells. With the RTG-2 system, effects have been consistently noted as soon as 6 days after the onset of exposures (total RNA, incorporation of thymidine and uridine) whereas with human cells, there was still no effect after 7 days. The know sensitivity of the aquatic organisms, in particular the rainbow trout, as well as the low cost, versatility and efficiency of cells in culture make possible the development of a unique and invaluable bioassay system for toxicity testing based upon the use of cultured trout cells in vitro. (Moore-IVI)
W84-02752

SAMPLING FREQUENCY FOR WATER QUALITY MONITORING: MEASURES OF EFFECTIVENESS,
Nichols Applied Management, Edmonton (Alberta).
D. Casey, P. N. Nemetz, and D. H. Uyeno.
Water Resources Research, Vol. 19, No. 5, p 1107-1110, October, 1983. 9 Ref.

Descriptors: *Monitoring, *Water quality, *Sampling frequency, Sampling, Water quality standards.

Selecting the sampling frequency is one of the most important tasks in the design of a regulatory water quality monitoring program. Two quantitative measures of the effectiveness of different sampling frequencies are proposed; these measures are intended to be used at the preliminary program design stage. The goal of the program is assumed to be the detection of violations of water quality standards. The first measure, M', gives the expected proportion of violations that will be detected. The second, M", is the ratio of the expected number of violated samples over the expected number of violations. By setting the average sampling interval equal to the average duration of a violation, the expected number of violated samples would equal the expected number of violations, since the errors caused by missing some violations and counting others more than one would tend to cancel out. The measures M' and M" will assist industrial dischargers and environmental agencies in the more effective design and assessment of water quality monitoring programs. (Moore-IVI)
W84-02757

POLYMERS TO SELECTIVELY REMOVE OXIDIZING ANIONS FROM NON-OXIDIZING ANIONS AND NO3(-) AND NO2(-) FROM POLLUTED WATERS,
Kansas State Univ., Manhattan. Dept. of Chemistry.
S. J. Chiou, T. Gran, C. E. Meloan, and W. C. Danen.

Analytical Letters, Vol. 16, No. A13, p 951-956, September, 1983. 3 Tab, 3 Ref.

Descriptors: *Nitrates, *Nitrites, *Polymers, Water analysis, Pollutant identification, Water pollution, Resins.

A copolymer of 1-phenyl-2-diethylaminoethyl-p-aminobenzoate and polyvinylbenzyl chloride was found to have a greater capacity for NO3(-) and NO2(-) than a previously reported nitron polymer but did not react as rapidly. The resin is readily regenerated with NH4OH or NH4Cl and is not affected by the pH of the water over the range of 4-10. A copolymer of 1-(4'-nitrophenyl)-2-diethylaminoethyl-p-nitrobenzoate and polyvinylbenzyl chloride was found to react nearly as fast as the nitron polymer and have a larger capacity for NO3(-) and NO2(-). (Author's abstract)
W84-02780

STATISTICAL APPROACH FOR DECIDING IF MUSSELS (MYTILUS EDULIS) HAVE BEEN COLLECTED FROM A WATER BODY POLLUTED WITH TRACE METALS,
Simon Fraser Univ., Burnaby (British Columbia). Dept. of Chemistry.
J. D. Popham, and J. M. D'Auria.
Environmental Science and Technology, Vol. 17, No. 10, p 576-582, October, 1983. 1 Fig, 7 Tab, 23 Ref. NSERC grants G0161 and G0507.

Descriptors: *Mussels, *Bioindicators, *Trace metals, *Statistical methods, Water pollution, Estuarine environment, Monitoring, Zinc, Lead, Heavy metals, British Columbia.

Two necessary requirements of monitoring programs are to be able to detect pollution effects against the background of the natural variability found in sentinal organisms and then to decide whether such an effect is sufficiently different from a reference population, e.i., represents a population of organisms from a polluted environment. A statistical approach is developed to decide whether specimens of Mytilus edulis (mussels), a sentinel organism for heavy metals, are inhabiting a water body that can be classified as polluted. Principal component analysis was applied to the correlation matrix of variates (Mn, Fe, Cu, Zn, and Pb concentrations, dry weight, wet weight, shell length, day/season of collection) measured in specimens collected monthly over a 12-month period from an unpolluted location in an estuary of southwestern British Columbia. Using the principal component scores determined for this set as a reference, a procedure is developed to decide whether similarly measured variates and related principal component scores for mussels collected from other locations indicate if these other water bodies were 'polluted' with heavy metals. Mussels which have very high concentrations of lead, zinc, copper, or iron indicate industrial pollution of the surrounding water. Using this method, it was possible to locate an area having less Zn and Pb pollution that the reference area, as well as areas with much higher levels. (Moore-IVI)
W84-02789

ANION CONTENT OF SNOW BY SUPPRESSED AND NON-SUPPRESSED ION CHROMATOGRAPHY,
Montana State Univ., Bozeman. Dept. of Chemistry.
D. R. Jenke, P. K. Mitchell, and G. K. Pagenkopf.
Journal of Chromatographic Science, Vol. 21, p 487-489, November, 1983. 2 Fig, 1 Tab, 14 Ref. EPA grant R-805935.

Descriptors: *Snow, *Chemical analysis, *Ion chromatography, Acid precipitation, Rocky Mountains, Chlorides, Nitrates, Sulfates, Air pollution, Fallout.

Both suppressed and non-suppressed ion chromatographic methods were employed in the analysis of snow sampled from the Rocky Mountains for Cl(-), NO3(-), and SO4(2-). By suppressed ion chromatography the concentration of these anion was found to be less than 1 mg/liter. These concentrations are lower than what can be determined using commerically available non-suppressed systems. To overcome this problem, the samples may be preconcentrated or a larger sample used. Due to complications arising on using a larger sample, in the absence of preconcentration, each sample must be analyzed twice by the non-suppressed ion chromatographic procedure. By comparison, the suppressed procedure is a factor of 10 more sensitive than this non-suppressed procedure. Even so, the results obtained by each of these procedures are not significantly different one from the other. (Baker-IVI)
W84-02798

VELOCITY PLOTS AND CAPTURE ZONES OF PUMPING CENTERS FOR GROUND-WATER INVESTIGATIONS,
Robert S. Kerr Environmental Research Lab., Ada, OK.
J. F. Keely, and C. F. Tsang.
Ground Water, Vol. 21, No. 6, p 701-714, November-December, 1983. 14 Fig, 4 Tab, 13 Ref. DOE contract DE-AC03-76SF00098.

Descriptors: *Groundwater pollution, *Water quality, *Pumping, Velocity plots, Plumes, Wells, Monitoring, Water quality control, Computers, Groundwater movement.

Several easily mastered methods for rapid estimation of the impact of pumping centers on nearby contaminant plumes are described and illustrated through the use of examples. Items considered include manual plots of velocity distributions; radial flow time-series models; and the RESSQ model, which is an expanded version of the radial flow time-series model, capable of incorporating the natural flow velocity and also capable of simulating more complex situations where several pumping wells and contaminant sources need to be evaluated simultaneously. While manual plots are easily constructed for a single well, use of computerized codes is much more efficient for more complex situations. Such codes can be devised to show not only the spatial distribution of contaminants, but also the contaminant concentration history at selected points. Use of such plots can help the field investigator select the most appropriate solutions to pollution problems. (Baker-IVI)
W84-02817

PYROLYSIS GAS CHROMATOGRAPHY-MASS SPECTROMETRY OF POLYCHLORINATED BIPHENYLS ON SEDIMENT,
University of Southern Mississippi, Hattiesburg. Dept. of Chemistry.
K. D. McMurtrey, N. J. Wildman, and H. Tai.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 6, p 734-737, December, 1983. 2 Fig, 5 Ref.

Descriptors: *Polychlorinated biphenyls, *Sediments, Lake sediments, Mass spectrometry, Gas chromatography, Pyrolysis, Soil analysis, Analytical methods.

Preliminary experiments have been performed, directed to assessing the use of pyrolysis/gas chromatography/mass spectrometry in determining polychlorinated biphenyl contamination of soils and sediments. In these experiments pyrolytic desorption at 1000 degrees C during 10 sec. was used to completely replace more lengthy wet chemical manipulations. The top 6-8 cm of sediment was collected from a lake in about 5 ft of water using a grab sampler. The total ion chromatogram displayed a number of large and small peaks with retention times between 3 and 10 min, while the reconstructed gas chromatograms were primarily composed of incompletely resolved clusters of peaks with retention times between 7.5 and 10 min. Mass spectrum of the 360 amu RCG peak eluting at 9.5 min shows evidence for chlorinated biphenyls with 4 and 6 chlorine atoms. It is clear that PY/GC/MS is able to demonstrate the presence of spiked PCBs on air-dried sediment at about the 10 ppm level. (Baker-IVI)
W84-02836

DETERMINATION OF MANGANESE AT NG/ML LEVELS IN NATURAL WATERS BY DIFFERENTIAL PULSE POLAROGRAPHY,
Pisa Univ. (Italy). Ist. di Chimica Analitica.
M. P. Colombini, and R. Fuoco.
Talanta, Vol. 30, No. 12, p 901-905, 1983. 6 Fig, 2 Tab, 14 Ref.

Descriptors: *Chemical analysis, *Natural waters, *Differential pulse polarography, Manganese, Estuarine environment, Iron, Chromium, Polarography.

An electrochemical procedure based on differential pulse polarography (DPP) is described for the determination of manganese at ng/ml levels. Chromium and iron can also be determined if the buffer system is changed. Polarographic determination of manganese in unbuffered natural waters was subject to strong interference because the chromium and iron signals overlap the manganese signal. In addition, the presence of nitrate enhances the chromium interference. In the proposed procedure based on DPP, citrate-borate, ascorbate-borate, and ascorbate-ammonia-ammonium chloride buffers allow the determination of ng/mg levels of manganese, manganese and iron, and manganese and chromium respectively, in natural waters. (Baker-IVI)
W84-02911

MONITORING OF EXCESS TEMPERATURE FIELDS,
Dansk Hydraulisk Inst., Hoersholm.
J. B. Nielson.
Water Science and Technology, Vol. 15, No. 10, p 165-175, 1983. 7 Fig, 5 Ref.

Descriptors: *Monitoring, *Water temperature, *Powerplants, *Effluents, Thermal pollution, Hydrology, Estuaries, Model studies, Environmental effects, Feasibility studies.

In the process of monitoring the impacts resulting from thermal pollution from power plants, the excess heat is widely used as an indicator. One single environmental standard may however not be appropriate to cover the different physical aspects of locations for such plants. A number of aspects have to be considered in monitoring of excess temperature: location and depth of meaurement; frequency of measurements; scanning technique to be used; other tools such as models. Investigations are divided into feasibility studies, site investigations (including modelling), and monitoring programs. Prediction and modelling of future impact, and the control and verification of actual impact, are closely interrelated. The monitoring program should ideally commence some years before start-up of the plant, and continue for 3-5 years after implementation, followed by reevaluations. The presentation is elucidated with examples of recent Danish monitoring programs, including a study of the expansion of the coal/oil fired powerplant Enstedvaerket from 200 MW to 860 MW, and a possible extension of Vestfraft powerplant in the estuary Ho Bay. Different locations demand different approaches in defining a monitoring program. (Moore-IVI)
W84-02942

5B. Sources Of Pollution

CHANGE IN THE CONCENTRATION OF SEVERAL TYPES OF PHOSPHATE FROM UPSTREAM TO DOWNSTREAM IN THE HAN RIVER ON THE KOREAN PENINSULA,
Hiroshima Univ. (Japan). Dept. of Environmental Studies.
K. Nakane, S.-U. Hong, and H.-S. Kang.
Japanese Journal of Limnology, Vol. 44, No. 3, p 190-205, July, 1983. 9 Fig, 6 Tab, 25 Ref.

Descriptors: *Phosphates, *Rivers, *Water pollution sources, *Han river, *Korea, Detergents, Fertilizers, Industrial wastes, Domestic wastes, Seasonal variations.

Sixteen sampling sites from upstream to downstream in the Han River on the Korean Peninsula

were used to investigate the concentration of nine types of phosphate throughout the four seasons in 1978-1979. All types of phosphate increased in concentration from upstream to downstream, especially in the Seoul City area. The ratio of particulate organic phosphate to total phosphate was constant from upstream to downstream irrespective of the total phosphate concentration level, suggesting that the plankton biomass increased in proportion to the total phosphate concentration. The ratio of dissolved ortho and hydrolizable phosphate to dissolved total phosphate increased from several percent in the upstream area to more than 90% in the downstream region. Results of phosphate analysis in thirteen tributaries showed that the increasing concentrations of phosphate, particularly ortho and hydrolizable phosphate from the upstream to downstream, were caused by drainage water from cultivated land in the middle reaches and mainly by domestic and industrial waste water in the downstream areas, which were heavily contaminated by fertilizer or synthetic detergent. (Baker-IVI)
W84-02480

SELECTIVE CHEMICAL LEACHING OF IRON, MANGANESE, COPPER AND CADMIUM IN RIVER SEDIMENT AT THE ERUPTION OF MT. ONTAKE,
Nagoya Univ. (Japan). Water Research Inst.
Y. Kitano, C. Tomiyama, and R. Fujiyoshi.
Japanese Journal of Limnology, Vol. 44, No. 3, p 215-224, July, 1983. 9 Fig, 5 Tab, 13 Ref.

Descriptors: *Volcanoes, *Leaching, *Heavy metals, *Mount Ontake, Japan, Iron, Manganese, Copper, Cadmium, Rivers, Water pollution sources, Hydrogen ion concentration, Sediments.

A large amount of volcanic ejecta was absorbed by rivers around Mt. Ontake (Japan) due to its volcanic eruption on October 28, 1979. The partitioning of iron, manganese, copper and cadmium into mineral fractions of river sediments has been investigated by a selective chemical leaching technique. The diagenetic behavior of these heavy metals in the river sediments was researched as a case study. The heavy metals in the river sediments were originally contained only in sulfide and silicate lattice fractions. Through the contact of sediment with water and air, the chemical form of iron changed to sulfate and hydroxide, manganese in the sulfide fraction mostly changed to the chemical forms of sulfate and silicate, and cadmium in sulfide fraction disappeared and was found only in the silicate fraction. The chemical form of copper did not change through the diagenetic process. The increase in river water pH after volcanic eruption presumably causes the dissolution of heavy metals. But the dissolved heavy metals are assumed to be removed effectively from the waters through coprecipitation with iron hydroxide which is formed due to the oxidation of iron and the pH increase in the river waters. (Moore-IVI)
W84-02482

LEACHING LOSSES OF NUTRIENTS IN OIL PALM PLANTATIONS DETERMINED BY TENSION LYSIMETERS,
Nigeria Inst. for Oil Palm Research, Benin City. Chemistry Div.
U. Omoti, D. O. Ataga, and A. E. Isenmila.
Plant and Soil. Vol. 73, No. 3, p 365-376, 1983. 1 Fig, 5 Tab, 18 Ref.

Descriptors: *Fertilizers, *Leaching, *Nigeria, *Oil palms, *Nutrients, Nitrogen, Potassium, Calcium, Magnesium, Sulfates, Chlorine.

The leaching losses of both native and applied fertilizer nutrients in young and adult oil palm plantations on an acid sand soil at the NIFOR Main Station in Central-Southern Nigeria were studied using alundum tension lysimeters placed at 60- and 150-cm depths. There were no significant differences in the leaching of the applied fertilizers between the young and adult plantations. Under an annual rainfall of 1923 mm, the average leaching losses of the applied fertilizer nutrients from both plantations were 11 kg N(34%), 10 kg K(18%), 43 kg Ca(172%), 14 kg Mg (60%), 12 kg SO4-S (14%) and 77 kg Cl (141%) per hectare. The average losses of the native nutrients were 43 kg N, 16 kg K, 144 kg Ca, 32 kg Mg, 67 kg SO4-S and 142 kg Cl. Although large, the annual losses of the native N, K, Ca and Mg represented only 6, 15, 4 and 3% respectively of the total initial amounts (total N and exchangeable cations) of these elements in the soil to a depth of 60 cm. Compared with losses under annual crops in areas of West Africa with much lower rainfall, the losses of the applied N, K and S are moderate. Taking into account the leaching losses and the annual nutrient requirements of an adult oil palm, the present annual rates of fertilizer application are inadequate and need to be increased for good vegetative growth and optimum bunch yield. (Moore-IVI)
W84-02506

TEMPORAL TRENDS TOWARD STABILITY OF HUDSON RIVER PCB CONTAMINATION,
New York State Dept. of Environmental Conservation, Albany.
R. J. Sloan, K. W. Simpson, R. A. Schroeder, and C. R. Barnes.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 4, p 377-385, 1983. 2 Fig, 2 Tab, 32 Ref.

Descriptors: *Polychlorinated biphenyls, *Fate of pollutants, *Water pollution, *Hudson River, *New York, Fish, Silt, Algae, Invertebrates, Multiplate residues, Aroclor.

Polychlorinated biphenyls (PCB) were used in the manufacture of electrical equipment at two sites on the upper Hudson River. PCB concentrations were determined in water, multiplate residues and fish from the upper and lower Hudson River from 1977 to 1981. Multiplate residues, composed of silt, algae and invertebrates collected on hardboard plates over a 5-wk exposure period, reflect PCB availability in the water column. Each year, all three sample types from the most highly contaminated portion of the upper Hudson River had higher PCB concentrations than those from the lower river by factors ranging from 1.4 to 4.8. Both river sections exhibited declining PCB concentrations over the course of the study, but the upper river response was more pronounced. For water, the greatest measured declines occurred in 1980 and 1981. The multiplate residues and fish experienced their initial significant declines in 1979. The multiplate sample concentrations rose sharply in 1981. Changes in total PCB for multiplate samples and fish were due almost entirely to changes in concentration of Aroclor 1016. From 1978-1981 there was no appreciable change in the concentration of Aroclor 1254. The surge of PCB in 1981 multiplate samples is not consistent with the water and fish data, and the reason for the increase is not known. (Moore-IVI)
W84-02530

UPTAKE AND CONCENTRATION FACTOR OF AROCLOR 1254 IN AQUATIC ORGANISMS,
Georgia Univ., Athens. Dept. of Food Science.
J. A. Gooch, and M. K. Hamdy.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 4, p 445-452, 1983. 3 Fig, 36 Ref. OWRT grant ERC 01-80-Ga.

Descriptors: *Polychlorinated biphenyls, *Aroclor, *Bioaccumulation, Ecosystems, Toxicity, Mosquitos, Bacillus, Guppies, Cichlids, Fish.

The uptake and concentration factor (CF) of Aroclor 1254 was followed in selected organisms representing a simple aquatic ecosystem. Four organisms were used: cells of PCB-resistant Bacillus spp., mosquito larvae (Aedes aegypti), guppies (Lebistes reticulatus), and cichlids (Cichlasoma facetum). For the two Bacillus strains, maximum uptakes of 22 and 24% were reached ater 72 hr incubation with CFs of 28 and 21. Very little effect on growth was noted. For mosquitos, the uptake by 3 day old larvae gradually increased to 5.1% after 96 hr; for 5 day old larvae there was a maximum uptake of 6.2% at 48 hr, declining to 2.6% at 96 hr. The CF of 3 day old larvae increased gradually to 553 after 96 hr. whereas that of 5 day old larvae reached its maximum of 638 at 48 hr. Guppies exposed to Aroclor 1254 all died within 3 wk. Direct uptake increased gradually to 3.6% after 96 hr with a CF of 198. The heads and fins of cichlids accumulated the greatest percentage of PCB (62.5% and 17.0%, respectively after 24 hr exposure). The CF tended to increase over time. (Moore-IVI)
W84-02532

HEAVY METAL CONTENT OF RAINWATER IN GENEVA, NEW YORK, DURING LATE 1982,
Hobart and William Smith Colleges, Geneva, NY. Dept. of Chemistry.
C. F. Aten, J. B. Bourke, and J. C. Walton.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 5, p 574-581, November, 1983. 5 Tab, 20 Ref.

Descriptors: *Rain, *Heavy metals, *Rural areas, *Geneva, *New York, Cadmium, Calcium, Magnesium, Zinc, Iron, Particulate matter, Fly ash, Fallout, Acid rain.

A determination was made of precipitation-borne fallout in a rural setting. Rainwater samples were collected at a relatively isolated site near Geneva, New York, from September through December of 1982 and at another similar site starting in late November. Samples were analyzed for 19 metallic elements, NO3(-), SO4(-2), pH and conductance. Six soil samples were analyzed for cadmium by inductively coupled plasma emission spectrometry. The acidity of the rainwater varied from pH 3.6 to 7.3 with overall average 4.2 in agreement with others for this region. In heavy rains the water collected later in the storm was generally less acidic and freer of other ions than the first rain to fall. The concentration of cadmium was surprisingly large, especially in some samples where values up to 1.52 micrograms/mL were found. The apparent cadmium fallout in rain is either a very recent development or simply a fluctuation. No correlation was found between cadmium and any other ionic species. The source of the cadmium fallout was not determined. (Baker-IVI)
W84-02537

IS THERE A BEST MODEL STRUCTURE; I. MODELING THE FATE OF A TOXIC SUBSTANCE IN A LAKE,
Canada Centre for Inland Waters, Burlington (Ontario).
E. Halfon.
Ecological Modelling, Vol. 20, No. 2/3, p 135-152, November, 1983. 2 Fig, 9 Tab, 13 Ref.

Descriptors: *Model studies, *Mathematical models, *Fate of pollutants, *Lakes, Pollutants, Food chains, Ecosystems, Lake sediments, Feeding, Fish, Benthos.

Three system methods are used to compare the internal connectivity and structural properties of two sets of fate models of a toxic substance in a lake. One set of models has six state variables and the second has ten. The methods used are a complexity measure c, an analysis of recycling perturbation following the addition or deletion of links among state variables, and a computation of direct and indirect flows among state variables. The purpose is to develop a model which reflects the cycling properties of an ecosystem without having too many unnecessary parameters. In ecological models many flows can not be measured and the parameterizations are uncertain. This fact is particularly true for fate models, where information on movement of toxic substances among compartments is often minimal. One set of models represents a general class of models, such as EXAMS, where no food chain transfer is included in the model structure and the second set represents a class of models with a food chain. Results show that for a six-compartment model, the best structure M4 includes several flows within the water column and the sediment compartments, including sedimentation and feeding of fishes from benthos. For the ten-compartment models, depending on the information available from the real system, structures T2 and T3 are the best. These two

structures include food chain transfers but no excretion or sediment uptake by fish and benthos. These models have the best network structure to represent the lake of interest. The models are insensitive to structural perturbation, and their structure minimizes any possible inappropriate parameterization because of alternative indirect connections among state variables. (Author's abstract)
W84-02539

FOREST ECOSYSTEM SO4-S INPUT-OUTPUT DISCREPANCIES AND ACID RAIN: ARE THEY RELATED,
B. Haines.
Oikos, Vol. 41, No. 1, p 139-143, 1983. 1 Tab, 38 Ref. NSF grant DEB 7714981.

Descriptors: *Acid rain, *Forests, *Sulfur, Sulfates, Tropical regions, Sulfuric acid, Soil chemistry, Water pollution sources, Rain forests, Biomass, Path of pollutants.

The inputs and outputs of SO4-S have been estimated for seven terrestrial ecosystems in the Americas. Five of the systems, an agricultural watershed, and two deciduous forests in the Southeastern United States, and a Central and a South American rainforest had an excess of inputs over outputs. The reported discrepencies were between +4 and +11 kg/ha/yr. Hypotheses to explain excess of inputs over outputs include: accumulation of S in biomass; accumulation of S in soil; conversion of SO4-S to organic S compounds which leave the system in drainage water; conversion of SO4-S to volatile S compounds which leave as gases; and estimation errors. Acid rain occurs at both rain forest sites. If the S were volatilized out of the forest, oxidized in the atmosphere to SO4, then washed out of the atmosphere by rain, the resulting quantity of H2SO4 would be sufficient to account for the rainfall acidity observed in the field in Central America. (Moore-IVI)
W84-02553

CHLORIDE POLLUTION OF THE GREAT LAKES,
Wisconsin State Lab. of Hygiene, Madison.
W. C. Sonzogni, W. Richardson, P. Rodgers, and T. J. Monteith.
Journal of the Water Pollution Control Federation, Vol. 55, No. 5, p 513-521, May, 1983. 3 Fig, 6 Tab, 57 Ref.

Descriptors: *Chlorides, *Great Lakes, *Water pollution sources, Industrial wastes, Phosphorus, Lake Michigan, Lake Superior, Lake Huron, Lake Erie, Lake Ontario.

Current estimates of chloride inputs to the Great Lakes from various sources are summarized. Changes that have occurred over past years are reviewed. The rate of change of chloride inputs to the Great Lakes, especially industrial discharges, seems to have stabilized or decreased in recent years. Nevertheless, chloride inputs are still high compared to the early 1900s and have resulted in elevated chloride concentrations in the lakes. Although near steady state chloride concentrations have been nearly reached in the lower lakes, concentrations in the upper lakes, which have flushing times on the order of hundreds of years are still building up. This is most dramatic in Lake Michigan, whose concentration is predicted to increase over the long term from 8 mg/L to nearly 20 mg/L if current loads are maintained. Observations from other lakes that have experienced conservative ion increases indicate that chlorides do not present an immediate high risk problem relative to others facing the lakes. Future phosphorus loads to the Great Lakes from municipal point sources should be reduced over 50% compared to mid-1970 levels. The extent to which the lakes actually respond to this reduction should provide valuable insight into the influence that conservative ions may have on water quality and a strategy for prudent management of chloride inputs to the Great Lakes, especially Lake Michigan. (Baker-IVI)
W84-02569

AEROSOL RELEASE OF CYANOPHAGES AND COLIFORMS FROM ACTIVATED SLUDGE BASINS,
North Carolina Univ. at Greensboro. Dept. of Biology.
R. E. Cannon.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1070-1074, August, 1983. 6 Tab, 9 Ref.

Descriptors: *Wastewater treatment facilities, *Aerosols, *Public health, *Coliforms, *Cyanophages, Activated sludge process, Wind, Temperature, Solar radiation, Seasonal variations, Bacteriophage, Greensboro, North Carolina.

The study was conducted at two secondary wastewater treatment plants in Greensboro, North Carolina. The North Buffalo plant processes 95% domestic and 5% industrial wastes. The South Buffalo Plant processes 30% domestic and 70% industrial wastes. LPP-cyanophages detected by the most probable number (MPN) method were found more frequently at South Buffalo than at North Buffalo. The fact that cyanophages are detected in chlorinated, sand filtered effluent indicates how hardy these organisms are compared to coliforms. The diffused aeration at North Buffalo caused little aerosol release of both coliforms and cyanophages. Mechanical aeration at South Buffalo produced extensive aerosolization of both cyanophages and coliforms from the activated sludge. Both the mechanical air sampler and Petri dish methods were effective in collecting cyanophages within 10 m of the tanks at South Buffalo. Isolated, non-systematic samplings by the Petri dish method, detected cyanophages in the air to 75 m downwind of the activated sludge basins at South Buffalo. Wind was the most important environmental factor that determined aerosol spread of cyanophages and coliforms. Solar radiation probably influenced survival of cyanophages and coliforms during the summer in the open Petri dishes, but the enclosed air sampler was able to detect cyanophages throughout the summer. Aerosols released from wastewater treatment plants may be a potential health hazard for personnel working at the plants and for individuals living nearby. Cyanophages can be used to rapidly and inexpensively measure the tendency towards aerosol spread of viruses at different locations. (Baker-IVI)
W84-02574

FATE OF TOXIC ORGANIC COMPOUNDS IN WASTEWATER TREATMENT PLANTS,
Halff (Albert H.) Associates, Inc., Dallas, TX.
A. C. Petrasek, I. J. Kugelman, B. M. Austern, T. A. Pressley, and L. A. Winslow.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1286-1296, October, 1983. 3 Fig, 5 Tab, 48 Ref.

Descriptors: *Wastewater treatment, *Organic compounds, Fate of pollutants, Activated sludge processes, Arochlor 1254, Heptachlor, Lindane, Toxaphene, Phenols, Pesticides, Phthalates, Polynuclear aromatic hydrocarbons, Priority pollutants.

The partitioning of 22 of the semivolatile organic priority pollutants in conventional wastewater systems was quantified. In the pilot-scale treatment sequence no changes in the concentrations of the compounds studied were observed as a result of either the sewer simulator or the aerated grit chamber. Removal in the primary clarifiers, computed from mass balances, was quite variable between groups but was relatively consistent within any given class of compounds. Partitioning to the primary sludge was an undefined function of the octanol/water partitioning coefficient. The overall removals by the treatment sequences were excellent, most of which were greater than 97%. Lindane, bis-(2-ethylhexyl)phthalate, di-n-butylphthalate, and pyrene are notable exceptions. The concentration factors for the primary sludge samples were significantly higher than those for the return activated sludge, but to keep these data in proper perspective the mass balance data must be cross referenced. A typical publicly owned treatment works, with the processes studied, significantly reduced the concentrations of the 22 organic priority pollutants, with the above noted exceptions. It is also noted that although some of the compounds were biodegraded, many of the chemicals studied were present in the sludges in very high concentrations. The fate of these materials in the solids handling processes is not known. (Baker-IVI)
W84-02598

LAKE PHOSPHORUS LOADING FROM SEPTIC SYSTEMS BY SEASONALLY PERCHED GROUNDWATER,
Geological Survey, Reston, VA.
R. J. Gilliom, and C. R. Patmont.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1297-1305, October, 1983. 1 Fig, 5 Tab, 29 Ref.

Descriptors: *Path of pollutants, *Phosphorus, *Lakes, *Water pollution sources, *Septic wastewater, Leaching, Soil properties, Groundwater pollution, Eutrophication, Domestic wastes, Drainage basins.

A case study was made of Pine Lake to determine how phosphorus is moving to lakes from old septic systems in glacial-till terrain. A regional analysis of septic-system P loading and this case study indicate that loadings of P to some lakes in the Puget Sound region are attributable to old septic systems. Effluent from each of the old systems studied was reaching the lake in perched groundwater flowing through soil overlaying less permeable glacial till. However, movement of more than 1% of effluent P to the lake was found to be rare. The loading of P to the lake by old septic systems is probably associated with only a few systems located in areas where soils are persistently saturated during the winter season. The probable relationship between septic-system P loading and the occurrence of persistently saturated soils indicates a possible explanation in addition to system age for the empirical relationship between the two. The relationship may be due in part to the location of old systems in seasonally wet areas compared to newer systems. Regulation and enforcement of construction practices were less stringent in the 1940s and 50s. (Baker-IVI)
W84-02599

HISTORY OF LAKE ACIDIFICATION AND AIR POLLUTION STUDIED ON SEDIMENTS IN SOUTH FINLAND,
Helsinki Univ. (Finland). Dept. of Botany.
K. Tolonen, and T. Jaakkola.
Annales Botanici Fennici, Vol. 20, No. 1, p 57-78, 1983. 19 Fig, 7 Tab, 87 Ref.

Descriptors: *Acid precipitation, *Air pollution, *Water pollution sources, *Finland, *Sediments, *Lake acidification, Paleolimnology, Lead radioisotopes, Diatoms, Varves, Lead, Zinc, Titanium, Cadmium, Copper, Mercury, Heavy metals, History.

Diatom and chemical analyses of the sediments of small oligohumous forest lakes on granitic bedrock with undisturbed (two lakes) or only slightly disturbed (two lakes) watersheds gave evidence of acidification by air-borne substances (acid precipitation). The varve (one lake) and lead-210 chronology (two lakes) indicated that this process commenced less than three decades to a few years ago. At the same time there was a considerable increase in the contents and sedimentation rates of lead, zinc, titanium, cadmium, copper and mercury. In the case of lead, however, the increase in deposition stated during the latter half of the 19th century. These changes were largely connected with accelerated atmospheric input. Element enrichment factors were calculated by dividing the concentrations in the surface sediments by the values in sediments deposited 150-200 years ago. After correction for input due to erosion from the catchment area, the enrichment factors were: Pb +28, Cd +9.4, Ca -7.1, Ti + 3.1, Zn +3.0, Hg +2.7, Fe -2.1, Mn and Al -2.0, Cu +1.6, Ni +1.2. (Author's abstract)
W84-02609

THE DEGRADATION OF DYESTUFFS: PART I, PRIMARY BIODEGRADATION UNDER ANAEROBIC CONDITIONS,
ETAD, Basel (Switzerland).
D. Brown.
Chemosphere, Vol. 12, No. 3, p 397-404, 1983. 3 Tab, 11 Ref.

Descriptors: *Dye industry wastes, *Degradation, Anaerobic conditions, Biodegradation, Dyes, Sludges, Sediments, Silt.

A method is described for measuring the primary biodegradability of water soluble dyestuffs under anaerobic conditions and gives the results obtained on 22 dyes of commercial significance. The dyestuffs tested included mordant blue 13, mordant black 9, basic red 18, acid yellow 151, direct red 7, acid red 114, direct blue 15, direct yellow 12, reactive black 5, acid blue 113, direct black 19, direct black 22, reactive blue 19, acid blue 80, acid blue 25, basic blue 22, basic green 4, direct yellow 11, reactive blue 21, basic blue 3, acid orange 3, and basic yellow 28. The results for the 4 azo and 6 diazo dyes show that virtually all the participating laboratories found very substantial biodegradation, and bearing in mind that the inoculum source and precise experimental details were different in each lab, these results are in good agreement with each other. With the two poly-azo dyes the results for direct black 19 all showed a moderate to substantial degree of degradation, but with direct black 22 the spread of results was from 0 to 100%. The four anthraquinone dyes showed results ranging from scarcely degraded in the case of acid blue 80, to substantial degradation for the other three. Of the remaining 6 miscellaneous dyestuffs no conclusions could be drawn with basic green 4. The other five all showed a moderate level of degradation. The results show that with the single exception of acid blue 80, all the dyestuffs tested can show a substantial degree of color removal and thus it seems a reasonable conclusion that the breakdown of dyestuff in the environment is likely to be initiated under anaerobic conditions. (Baker-IVI)
W84-02623

TCDD IN BOTTOM SEDIMENTS AND EEL AROUND A REFUSE DUMP NEAR AMSTERDAM, HOLLAND,
Amsterdam City Environmental Health Research Lab. (Netherlands).
H. Heida.
Chemosphere, Vol. 12, No. 4/5, p 503-509, 1983. 4 Fig, 2 Tab, 11 Ref.

Descriptors: *Organochlorine pesticides, *Sediment contamination, *Waste dumps, *Netherlands, Chlorinated hydrocarbons, Chlorobenzenes, Chlorophenols, Hexachlorocyclohexane, Dioxins, Industrial wastes, Water pollution sources, Eels, Bioaccumulation, Partition coefficients.

A refuse dump located north of Amsterdam (Netherlands), heavily contaminated with organochlorine waste compounds from 2,4,5-T production, pollutes the surrounding area through the main drainage canal. The dump is situated in a wetland of peat soil character used for dairy farming. Chlorobenzenes, chlorophenols, hexachlorocyclohexanes and the chlorodioxins, mainly 2,3,7,8-TCDD, were identified in the sediments. Analysis of bottom sediments in the drainage canal was positive for 2,3,7,8-TCDD at concentrations beween 50 and 5,000 ppt on a dry weight basis. The lowest concentrations occurred in a small pond about 1 km from the dump. Analysis of sediment samples by two laboratories showed a fairly good agreement. Eel caught from the same aquatic habitat had about 1 ppt of 2,3,7,8-TCDD in its tissue. This was lower than calculated levels, based on knowledge of water-sediment partition coefficient and biological accumulation factors. (Moore-IVI)
W84-02624

FATE OF 1,3,6,8-T4CDD IN AN OUTDOOR AQUATIC SYSTEM,
Manitoba Univ., Winnipeg. Dept. of Soil Science.
R. L. Corbet, D. C. G. Muir, and G. R. B. Webster.
Chemosphere, Vol. 12, No. 4/5, p 523-527, 1983. 5 Fig, 1 Tab, 7 Ref.

Descriptors: *Fate of pollutants, *Tetrachlorodibenzo-p-dioxin, Sediments, Vegetation, Fish, Pesticide residues, Fathead minnows, Trout, Water pollution, Dioxins.

Outdoor ponds (5200 + or - 185 L) were treated with 0, 100, 250, and 1000 ng/L C-14 1,3,6,8-tetrachlorodibenzo-p-dioxin (1,3,6,8-T4CDD). Air, water, sediment, vegetation, and fish samples were taken at regular intervals over 90 d, with a final sample at 355 d. Within 96 h, 89-96% of the C-14 had moved from the water column (t 1/2 = 25 h). Volatile loss of 1,3,6,8-T4CDD was greatest during the first day after treatment. Labelled material also moved into the sediment attaining steady state levels of 0, 4.7, 10.3, and 20.5 ng/g dry wt respectively after 8 d. In a separate laboratory study, fathead minnows and rainbow trout took up C-14 1,3,6,8-T4CDD rapidly, and clearance rate constants were 0.211 + or - 0.023/d and 0.158 + or - 0.014/d. (Author's abstract)
W84-02625

A QUANTITATIVE WATER, AIR, SEDIMENT INTERACTION (QWASI) FUGACITY MODEL FOR DESCRIBING THE FATE OF CHEMICALS IN LAKES,
Toronto Univ. (Ontario). Dept. of Chemical Engineering and Applied Chemistry.
D. Mackay, M. Joy, and S. Paterson.
Chemosphere, Vol. 12, No. 7/8, p 981-997, 1983. 3 Fig, 4 Tab, 13 Ref.

Descriptors: *Fugacity, *Lake sediments, *Fate of pollutants, Mathematical models, Advective flow, Volatilization, Resuspension, Deposition, Burial, Air pollution.

A mathematical model was formulated to describe the fate of a chemical in a sediment-water-air system as may occur in a contaminated lake. Equilibrium is quantified using the fugacity concept and fugacity capacities. Expressions are written in the form of fugacity equations with a common D parameter, or kinetic coefficient, for processes of advective flow, volatilization, sediment resuspension, deposition and burial, wet and dry atmospheric deposition, and degrading reactions. By describing these diverse processes by identical mathematical expressions, their relative rates are more easily compared and algebraic manipulation is facilitated. Several analytical solutions are possible: a steady state condition; a water and sediment unsteady state condition; a steady state water, unsteady state sediment condition; and a steady state sediment, unsteady state water condition. Numerical solution can also be used to treat more complex situations when emissions or rate parameters vary with time. (Moore-IVI)
W84-02626

A QUANTITATIVE WATER, AIR, SEDIMENT INTERACTION (QWASI) FUGACITY MODEL FOR DESCRIBING THE FATE OF CHEMICALS IN RIVERS,
Toronto Univ. (Ontario). Dept. of Chemical Engineering and Applied Chemistry.
D. Mackay, S. Paterson, and M. Joy.
Chemosphere, Vol. 12, No. 9/10, p 1193-1208, 1983. 6 Fig, 3 Tab, 1 Ref.

Descriptors: *Fugacity, *Fate of pollutants, *Rivers, *Mathematical models, Sediment-water interactions, Air-water interactions, Model studies, Solute transport, Particulates, Resuspension, Advection, Volatilization, Deposition.

The QWASI fugacity model has been reformulated in a coordinate system to apply to rivers. An analytical solution describes the steady state fate of a chemical in a river of constant properties in which there is interaction with air and sediment. Transport and transformation processes included are advective flow (in solution and in association with suspended particles), reaction in sediment and water, sediment deposition, resuspension and burial, and air-water exchange processes of volatilization, adsorption, and wet and dry deposition with particulate matter. The equations are formulated in terms of fugacities with common transport and transformation parameters. The model may be useful for estimating the distance downstream that a particular chemical emission may persist, thus assisting regulatory measures concerned with defining acceptable emissions. A steady state sectioning model version is mathematically equivalent to the analytical solution. An unsteady state version is illustrated for the case of a river which is recovering from previous contamination. In most cases it will be valid to assume that the water will adopt a steady state concentration relative to the sediment. The models can be used to quantify the behavior of chemicals in rivers and to obtain insights into the dominant transport and transformation process and thus help to assess the likely impact on such aquatic systems. (Moore-IVI)
W84-02630

A RADIOTRACER STUDY OF AIR-WATER EXCHANGE OF SYNTHETIC ORGANIC COMPOUNDS,
Texas A and M Univ., College Station. Dept. of Chemistry.
E. Atlas, A. Velasco, K. Sulliva, and C. S. Giam.
Chemosphere, Vol. 12, No. 9/10, p 1251-1258, 1983. 3 Fig, 3 Tab, 17 Ref.

Descriptors: *Air-water interfaces, *Path of pollutants, *Organic compounds, Salinity, Henry's Law, Chlorination, Pollutants.

A simple radiotracer technique determined Henry's Law Constants for some prevalent organic pollutants including hexachlorobenzene, PCBs, and di-n-butyl phthalate. The results obtained with this technique were in good agreement with the few other data available on the subject. The data suggest that the partition coefficient of PCB decreases slightly with increasing degree of chlorination. The increase in salinity from distilled water to seawater increases the partition coefficients of HCB, BCP, and PCB by 1.4, 1.5, and 2.1 times, respectively. Naturally occurring organics dissolved in seawater or lake water caused no appreciable effect on the measured partition coefficients of the test compounds. (Baker-IVI)
W84-02632

PARTICULATE FLUX AT THE BOTTOM OF LAKE ONTARIO,
National Water Research Inst., Burlington (Ontario).
For primary bibliographic entry see Field 2H.
W84-02633

MICROBIAL METABOLISM OF N-PHENYL-1-NAPHTHYLAMINE IN SOIL, SOIL SUSPENSIONS, AND AQUATIC ECOSYSTEMS,
Syracuse Research Corp., NY.
A. Rosenberg.
Chemosphere, Vol. 12, No. 11/12, p 1517-1523, 1983. 6 Fig, 12 Ref. AF contract F49620-77-C-0027.

Descriptors: *N-Phenyl-1-naphthylamine, *Microbial degradation, *Fate of pollutants, Aquatic environment, Soil microorganisms, Wastewater, Amines, Additives, Metabolism.

N-Phenyl-1-naphthylamine (PNA) is a lubricant additive widely used in Air Force operations. The chemical may be introduced into the aquatic or terrestrial environments as a result of accidental spills, waste discharge effluent from manufacturing plants, or during its use and disposal. PNA was degraded and mineralized in nonsterile aquatic and terrestrial samples. Degradation in unsupplemented sewage and lake water was detected in 3 to 6 days with half-lives of 5 and 10 days, respectively. In sewage and lake water supplemented with a readily degradable carbon source, degradation began in 1 and 5 days with half-lives of 2 and 8 days, respectively. Sewage samples converted between 20 and 30% of C-14 labeled PNA to labeled CO2 in 35 days while lake water samples reached 10% conversion to labeled CO2 in 12 days. Soil samples and soil suspensions converted from 15 to 35% of

C-14-PNA to labeled CO2 in 11 days. PNA was microbiologically converted in lake water to two products that were tentatively identified by gas-liquid chromatography and mass spectroscopy as dihydroxy and N-acetyl derivatives. The extent and rate of microbial attack on the compound were dependent on the amount of organic matter present. The disappearance of the parent compound may not indicate removal of the hazardous potential of the molecule from the environment. (Moore-IVI)
W84-02634

POLLUTION SOURCE ANALYSES USING 1-DIMENSIONAL TIME SERIES,
Illinois State Environmental Protection Agency, Springfield.
D. J. Schaeffer, C. Corley, and H. Chien.
Environmental Management, Vol. 7, No. 5, p 421-426, 1983. 1 Fig, 3 Tab, 14 Ref.

Descriptors: *Water pollution sources, *Lake Holiday, *Illinois, *Bacteria, Nutrients, Effluents, Reservoirs, Coliforms, Streptococcus, Artificial lakes.

Lake Holiday, a human-made recreational lake in northern Illinois, was threatened with closure due to high bacterial levels. A factorially designed experiment with multivariate responses was developed to study and identify the main sources of pollution. Data on total coliform, fecal coliform, fecal streptococci, dissolved oxygen, pH, ammonia-N, total phosphorus, nitrate/nitrite-N were analyzed using regression models describing dam spillway loads as a function of source loads and time. The results suggest that the relationships among source, time, and load are complex, even though only two sources account for most of the lake's loading. Stevens Brook, which receives the discharge from the Somonauk Sewage Treatment Plant, and Somonauk Creek, which is the major drainage, contribute high loads of bacteria and nutrients to the lake. The influent loads contributed to the lake are discharged at the dam over about 4 weeks. (Author's abstract)
W84-02642

CHLORINATED ACIDS AND CHLORAL IN DRINKING WATER,
Massachusetts Univ., Amherst. Dept. of Chemistry.
P. C. Uden, and J. W. Miller.
Journal of the American Water Works Association, Vol. 75, No. 10, p 524-527, October, 1983. 3 Fig, 2 Tab, 18 Ref. DOE contract DE-AC02-77EV-04320.

Descriptors: *Chlorination, *Drinking water, Organic compounds, Dichloroacetic acid, Trichloroacetic acid, Chloral hydrate, Chloroform, Water treatment.

The quantitation of three compounds, dichloroacetic acid (DCAA), trichloroacetic acid (TCAA) and chloral, in addition to chloroform, was carried out using samples from a municipal water supply system. Concentrations of DCAA and TCAA were similar in the range of 30 to 160 micrograms/liter and comparable to those for chloroform. Those of chloral were lower by a factor of about 10 but were still readily measurable by using the microwave plasma emission detector (MED). All of these compounds could also be measured with other detection systems that are selective for halogenated compounds. All four of the above compounds resulted from municipal chlorination. The concentrations of these organics depended on the amount of natural organics in the untreated water. If residual chlorine were present after chlorination, the concentrations depended on the contact time between organics and residual chlorine. Qualitative studies showed that all of the chlorinated compounds found in finished waters were also formed in the chlorination of soil fulvic acids. (Baker-IVI)
W84-02677

NONPOINT WATER QUALITY CONTRIBUTIONS FROM LAND USE,
Arizona Univ., Tucson. School of Renewable Natural Resources.
D. C. Wilkin, and R. W. Jackson.
Journal of Enviromental Systems, Vol. 13, No. 2, p 127-136, 1983-84. 1 Fig, 2 Tab, 8 Ref.

Descriptors: *Nonpoint pollution sources, *Land use, *Water pollution sources, Phosphorus, Nitrates, Water quality, Sediment barriers, Floodplains, Watershed management, Trap efficiency, Reservoirs.

Stream loads of total phosphorus and nitrate-nitrogen were studied as a function of land use in a midwestern watershed of 5,853 sq km by means of ordinary least squares (OLS) regression analysis. The purpose was to test the general hypothesis that the variance in chemical water quality from undefined sources is a function of land use within the watershed, and to begin to study the hypothesis that land use near the stream is more important than land use far from the stream in affecting water quality from nonpoint sources. Results support both hypotheses. Further, these results suggest the importance of considering the means by which chemicals are delivered to the stream. Nitrate-nitrogen and phosphorus can apparently both be purposely intercepted, but by different means because of their different delivery systems. Nitrate-nitrogen can be intercepted by removal of fast-growing floodplain crops, and phosphorus by sediment barriers outside the floodplain. Evidence also suggests trap efficiency in reservoirs is important in improving downstream water quality. (Author's abstract)
W84-02683

BEHAVIOR OF COPPER IN SOUTHEASTERN UNITED STATES ESTUARIES,
Skidaway Inst. of Oceanography, Savannah, GA.
H. Windom, G. Wallace, R. Smith, N. Dudek, and M. Maeda.
Marine Chemistry, Vol. 12, p 183-193, 1983. 10 Fig, 14 Ref. DOE contract DE-AS09-76EV00890.

Descriptors: *Copper, *Path of pollutants, Savannah River, Ogeechee River, Estuaries, Estuarine environment, Georgia, Sediment transport, Salinity, Nearshore processes, Seasonal variation.

Discharges of the Savannah and Ogeechee Rivers vary seasonally with highest runoff generally occurring between January and June. During low runoff dissolved copper concentrations in the river are low. Exchangeable copper on particles and colloids also may be low. Therefore, release in the low salinity region of the estuaries is small. Because of the low discharge, however, the estuarine-nearshore residence time of water is relatively long and copper release from bottom or resuspended sediment is significant. During low discharge, high salinity waters are closer to shore and overlie more copper rich fine grain sediments which provide a greater source for release. Higher temperatures and increasing reaction rates during summer low runoff conditions may also enhance copper release, leading to a higher zero salinity copper concentration intercept of the tangent to the high salinity portion of the mixing curve. During high runoff, riverine dissolved and possibly exchangeable copper concentrations are greater than during periods of low runoff. Significant amounts of copper are released from particles and/or colloids at low salinity possibly followed by some copper removal. Removal, however, is offset and exceeded by copper release from estuarine sediments. Because of the short nearshore residence time of water during high discharge, sediment release is less significant, resulting in a lower zero salinity copper concentration intercept of the tangent to the high salinity portion of the mixing curve. (Baker-IVI)
W84-02690

REQUIREMENTS FOR MODELING TRACE METAL PARTITIONING IN OXIDIZED ESTUARINE SEDIMENTS,
Geological Survey, Menlo Park, CA.
For primary bibliographic entry see Field 2L.
W84-02692

SOURCES OF NITRATES IN GROUNDWATER OF THE COASTAL PLAIN OF ISRAEL; EVOLUTION OF IDEAS,
Ministry of Agriculture, Tel-Aviv (Israel).
D. Ronen, Y. Kanfi, and M. Magaritz.
Water Research, Vol. 17, No. 11, p 1499-1503, 1983. 3 Fig, 2 Tab, 21 Ref.

Descriptors: *Nitrates, *Groundwater pollution, *Israel, Water pollution sources, Fertilizers, Coastal Plain Aquifer, Wastewater, Soil chemistry, Irrigation water, Organic matter.

In 1981 the Coastal Plain aquifer of Israel had an average nitrate concentration of 53 m/l of NO3. This phreatic aquifer supplies 25% of the water consumed in the country through 1600 pumping wells. This problem is especially severe because Israel has only one integrated water system that supplies water for municipal, agricultural and industrial use. The quantitative nitrogen balance of the aquifer is analyzed based on the reconstructed average nitrate trends in groundwater. Most of the nitrates found today in the aquifer reached the water table in the period 1930-1960, which suggests that the mineralization of the organic matter in the soil and unsaturated zone was the main source of nitrate pollution. The steep rise in the average nitrate concentration of groundwater over the last 50 years was the inevitable result of the agricultural development of the area. If no large transient nitrate reservoir exists in the unsaturated and water table zones, it is expected that the average nitrate content of groundwater will decrease with time. The slight nitrogen input to groundwater from fertilizers, sewage, animal excreta, irrigation water, rainwater and solid waste, suggests that previous prediction models and managerial and technical recommendations should be reevaluated. (Murphy-IVI)
W84-02700

FECAL COLIFORM DISAPPEARANCE IN A RIVER IMPOUNDMENT,
Michigan Univ., Ann Arbor. Dept. of Environmental and Industrial Health.
J. J. Gannon, M. K. Busse, and J. E. Schillinger.
Water Research, Vol. 17, No. 11, p 1595-1601, 1983. 4 Fig, 7 Tab, 25 Ref.

Descriptors: *Fecal coliforms, *Reservoirs, *Sedimentation, Balancing reservoir, Bacteria, Lake restoration, Drainage basins, Storm drainage, K rates, Solar radiation, Ypsilanti, Michigan, Huron River, Ford Lake, Chick equation, Channel flow.

During the summer of 1979, intensive fecal coliform disappearance studies were conducted in Ford Lake, an artificial main river impoundment at the lower end of the Huron River drainage basin, downstream from Ypsilanti, Michigan. Ford Lake receives all upstream flow of 2072 sq km of drainage in addition to fourteen storm drains which discharge directly into the lake. The lake has a surface area of about 32,515,000 sq m, a volume of about 151,510,000 cu m, a length of about 3658 m and a mean depth of 4.66 m. In the more active upper section of the lake, the mean depth is 0.9 to 1.83 m. During dry weather, using a dye tracer for timed collection, an overall daytime fecal coliform disappearance K rate of 0.4/h was calculated from a water column in support of the hypotheses that sedimentation of fecal coliform organisms attached to solid particles partially accounts for the high fecal coliform disappearance rate in the channel area of the lake. From the rooftop results it is seen that reduced light K rates are substantially lower than the normal sunlight K rates, indicating natural level substantially influences the fecal coliform disappearance rate. Two types of wet weather were documented: where a substantial increase in flow occurred due to an isolated upriver storm; and as a result of two different storm events in the Ford Lake area itself. In both cases, Ford Lake was effective in substantially reducing the large fecal coliform contribution. (Murphy-IVI)
W84-02706

RATES OF DISSOLUTION OF CONSTITUENT ORGANIC CONTAMINANTS FROM COAL LIQUEFACTION OIL FILMS INTO WATER,

Oak Ridge National Lab., TN. Environmental Sciences Div.
S. E. Herbes, G. R. Southworth, and C. P. Allen.
Water Research, Vol. 17, No. 11, p 1639-1646, 1983. 5 Fig, 2 Tab, 27 Ref. DOE contract W-7405-eng-26.

Descriptors: *Oil pollution, *Coal liquifaction, *Organic compounds, *Dissolution, Phenols, Anilines, Naphthalene, Solubility, Coal liquids, Oil spills, Partition coefficient, Turbulence, Fate of pollutants.

Commercial coal liquifaction facilities are likely to be constructed within the coming decade. Because plants will require large amounts of water, they may be sited along major rivers, so that spills of liquid product into rivers are a possible environmental hazard. To facilitate development of a model for dissolution of toxic contaminants from synthetic coal liquids in the event of an accidental riverine spill, dissolution rates from oil films overlying water in a stirred laboratory extractor were measured by solvent partitioning and gas chromatography. Major water-soluble contaminants identified in five coal liquids were phenol, aniline and their C1-C3 alkylated derivatives. First-order rate constants for approach to equilibrium were related to the oil-water partition coefficient in an inverse nonlinear relationship; data agreed well with a two-film model. Overall mass transfer coefficients varied nearly 1000 from phenol to naphthalene in one oil. Oil-phase mass transfer coefficients were inversely related to oil viscosity. Under riverine turbulence conditions in which spilled oil is not dispersed by mixing into the water column, phenols and anilines in coal liquids will dissolve far more rapidly than one- and two-ring aromatic hydrocarbons. Other weathering processes may alter behavior of a spilled coal liquid and will complicate application of the dissolution model. (Moore-IVI)
W84-02711

EVALUATING A MASS TRANSFER MODEL FOR THE DISSOLUTION OF ORGANICS FROM OIL FILMS INTO WATER,

Oak Ridge National Lab., TN. Environmental Sciences Div.
G. R. Southworth, S. E. Herbes, and C. P. Allen.
Water Research, Vol. 17, No. 11, p 1647-1651, 1983. 3 Fig, 2 Tab, 13 Ref. DOE contract W-7405-eng-26.

Descriptors: *Oil pollution, *Mass transfer, *Dissolution, Organic compounds, Mathematical models, Solubility, Oil-water interfaces, Oil spills, Partition coefficient, Synthetic oils.

Because the environmental impact of an oil spill is determined in part by concentrations of toxic materials in the oil and by the rates at which those toxicants move from the oil to the water, the ability to predict the rates at which various toxic constituents of synthetic oils are transferred from floating oil films to the underlying water is helpful to understanding the potential environmental effects of synthetic oil spills. A mass-transfer model analogous to one used to describe the volatilization of organics from natural waters was used to describe the dissolution of constituent organics from a floating oil film into the underlying water. The rate of dissolution of a substance from oil to water is highly dependent upon the partition coefficient, P. The partition coefficient also sets the maximum attainable aqueous concentration for a given initial concentration of the substance in the oil phase. Rates of dissolution were observed to vary with properties of the solute, P, the oil (viscosity, P, oil depth) and the environment (oil and water mixing, water depth). The observed rates of dissolution of chemicals from a low-viscosity oil (heptane) varied by a factor of about 10000 between the most rapidly and most slowly dissolving materials. (Moore-IVI)
W84-02712

MONITORING ANIONIC SURFACTANTS AT A SEA OUTFALL, HALIFAX HARBOUR, CANADA,

Dalhousie Univ., Halifax (Nova Scotia).
M. J. Gagnon.
Water Research, Vol. 17, No. 11, p 1653-1659, 1983. 6 Fig, 1 Tab, 26 Ref.

Descriptors: *Marine environment, *Anionic surfactants, *Halifax Harbor, Nova Scotia, Effluents, Monitoring, Tracers, Water pollution, Path of pollutants.

Anionic surfactants are typically introduced to the marine environment via outfall discharges. Monitoring of the concentration possibly can help to elucidate the behavior of these compounds and the effluent in the natural environment. Halifax Harbor and its natural extension, the Northwest arm, were chosen as sites for a detailed study of anionic surfactants in the marine environment because sewage discharge is not treated in any way. A concentration range between 1.0 and 200 micro g/l can be found in polluted areas. The highest concentrations were detected near the point source. In Halifax Harbor, high concentrations of surfactants are associated with the presence of rising plumes. Wind and tidal currents can affect both the spreading of these compounds and the waste field. Anionic surfactants can be used as tracers, in well defined effluents, but they possibly suffer a certain level of biodegradability. The proper choice of one or a combination of tracers may render wastewater effluent monitoring a routine and precise exercise when low concentrations of effluents are encountered in the marine environment. (Moore-IVI)
W84-02713

LABORATORY AND FIELD ANALYSIS OF PENTACHLOROPHENOL (PCP) ACCUMULATION BY SALMONIDS,

Canada Centre for Inland Waters, Burlington (Ontario).
A. J. Niimi, and C. Y. Cho.
Water Research, Vol. 17, No. 12, p 1791-1795, 1983. 2 Fig, 3 Tab, 20 Ref.

Descriptors: *Trout, *Pentchlorophenol, *Bioaccumulation, Water pollution effects, Fish, Wood preservatives, Pesticides, Phenols, Lake Ontario.

Rainbow trout were fed diets containing 10-3000 micro g/kg pentachlorophenol (PCP) for up to 110 days to examine its accumulation. Fish fed the 10 micro g/kg diet maintained whole body levels of 2 micro g/kg PCP over the study period, while PCP levels in those fed the 3000 micro g/kg diet increased to 40 micro g/kg after 40 days, then decreased thereafter to 20 micro g/kg at the end of the study. The biological half-life of PCP in trout was estimated to be approximately 7 days. PCP concentrations in the liver and gall bladder of fish fed the 3000 micro g/kg diet were substantially higher than those monitored in the remainder of the fish. The PCP concentrations monitored in fish during the food uptake and elimination studies were not acutely toxic to trout. PCP levels in six species of fish representing two trophic levels from Lake Ontario were also monitored; most species contained 1-10 micro g/kg PCP. Rainbow trout collected in the Credit River had PCP levels averaging 24 micro g/kg. The results suggest the uptake of PCP from water would be a more important pathway for its accumulation by fish than its intake from food when viewed from an environmental perspective. Biliary excretion could represent a major clearance pathway for trout. (Moore-IVI)
W84-02722

EMPIRICAL RATE EQUATION FOR TRIHALOMETHANE FORMATION WITH CHLORINATION OF HUMIC SUBSTANCES IN WATER,

Yokohama National Univ. (Japan). Dept. of Safety and Environmental Engineering.
K. Urano, H. Wada, and T. Takemasa.
Water Research, Vol. 17, No. 12, p 1797-1802, 1983. 12 Fig, 19 Ref.

Descriptors: *Trihalomethanes, *Chlorination, *Humic acids, Drinking water, Halogenated hydrocarbons, Water treatment, Sagami River, Japan.

Trihalomethane (THM) in drinking water is formed by chlorination of humic substances. The rates of THM formation in aqueous solution of humic acid were examined under various conditions. A rate equation was obtained empirically. The activation energy was obtained as 37 kJ/mol. To test the applicability of the proposed rate equation to the THM formation from actual river and lake waters, chlorination tests on a sample of river water were carried out. River water from Sagami River, whose total organic carbon concentration was 5.0 mg/l, was chlorinated at 20 C by dosing hypochlorite. The data fitted and could be expressed by the rate equation. THM concentrations in drinking water for each water distributing area can be predicted by this equation. Precursor in each water source can be characterized and variations with season and water teatment conditions can also be evaluated. (Moore-IVI)
W84-02723

ION EXCHANGE AND HYDROLYSIS OF TYPE A ZEOLITE IN NATURAL WATERS,

Illinois Inst. of Tech., Chicago. Pritzker Dept. of Environmental Engineering.
H. E. Allen, S. H. Cho, and T. A. Neubecker.
Water Research, Vol. 17, No. 12, p 1871-1879, 1983. 5 Fig, 6 Tab, 27 Ref.

Descriptors: *Zeolite, *Ion-exchange, *Hydrolysis, *Fate of pollutants, Trace metals, Cadmium, Copper, Nickel, Lead, Detergents.

Type A zeolite is a synthetic, crystalline aluminosilicate used as a builder in laundry detergents. The ion exchange behavior and hydrolysis rate of Type A zeolite were studied in a variety of artificial and natural surface water samples at zeolite A and trace metal concentrations characteristic of what could occur in receiving waters. Type A zeolite hydrolyzed extensively in the test waters at rates which were strongly dependent on hydrogen ion concentration. Half lives of 1-2 months were typical for waters at a neutral pH. The extent of trace metal ion exchange was low (<10%) for the metals Cd, Cu, Ni and Zn. Only lead is likely to be exchanged to an extent greater than 10% and then only in waters containing high (1 mg/l) levels of zeolite. Under typical conditions, zeolite concentrations will be much less and lead exchange will be considerably less than 10%. The use of the zeolite in detergents will result in little effect on the trace metal distribution of surface waters owing to the low degree of ion-exchange by the zeolite and its hydrolysis products. (Moore-IVI)
W84-02729

MODELLING NITRIFICATION EFFECTS ON THE DISSOLVED OXYGEN REGIME OF THE SPEED RIVER,

Gore and Storrie Ltd., Toronto (Ontario).
T. P. H. Gowda.
Water Research, Vol. 17, No. 12, p 1917-1927, 1983. 6 Fig, 3 Tab, 22 Ref.

Descriptors: *Nitrification, *Dissolved oxygen, *Speed River, *Ontario, Computer models, Nitrogenous oxygen demand, Biochemical oxygen demand, Photosynthesis, Aeration, Aquatic plants, Water pollution.

Field studies on nitrification in an 11 km stretch of the Speed River below Guelph (Ontario) are described. The data, collected during three intensive surveys in spring-summer 1976 and winter 1977, were used to calibrate and verify a steady-state dissolved oxygen (DO) model which incorporates the effects of carbonaceous and nitrogenous oxygen demand (CBOD and NOD), plant and algal respiration and photosynthesis, and reaeration. The model calibration result for one of the survey conditions includes comparisons between the corresponding observed and predicted values of CBOD, NOD and daily minimum and maximum DO. The comparisons of the first three sets of parameters were satisfactory, but the predicted maximum DO values were generally higher than the observations. The model verification results for two other survey conditions were somewhat similar to those of the calibration study. Predictions of the relative effects of various sinks on the minimum DO levels under one of the survey conditions indicate that instream nitrification alone causes a

DO deficit of about 4.5 mg/l; in contrast, the deficits due to CBOD and respiration were in the order of 1 mg/l only. The model was also used to predict spatial DO distributions under several streamflow and temperature regimes. For each case, computer runs were made with NOD concentrations resulting from a conventional secondary (i.e. non-nitrified) effluent and a nitrified effluent. The predictions indicate that the minimum DO level increases with an increase in streamflow and a decrease in temperature. In the case of non-nitrified effluents, anoxic conditions are predicted to occur at about 25 C when streamflow rates are lower than about 1 cu m/s; whereas in-plant nitrification would result in daily minimum DO levels of 4 mg/l or greater. The predictions also show the occurrence of two DO sags in the study stretch, one being mainly due to a high degree of nitrification, while the other is due to the combined effect of all of the DO sinks. (Author's abstract)
W84-02733

A CHEMILUMINESCENCE TECHNIQUE FOR STUDYING DYNAMIC BEHAVIOR OF TRACE ELEMENT SPECIES IN ENVIRONMENTAL SYSTEMS,
Maine Univ. at Orono. Dept. of Chemistry.
S. Amirhaeri, R. Koons, M. Martin, and H. Patterson.
Water Research, Vol. 18, No. 1, p 87-90, 1984. 4 Fig, 9 Ref. OWRT grant B-D16-ME.

Descriptors: *Chemiluminescence, *Adsorption, *Kinetics, *Trace elements, Chromium, Cobalt, Iron, Thermodynamics.

The technique of chemiluminescence (CL) has been used to study the kinetics of association of aqueous chromium(III) with iron oxide for Cr(III) concentrations in the ppb range. The results have been compared with atomic absorption experiments for Cr(III) concentrations in the ppm range. Further, the CL technique has been used to study the kinetics of reaction of Cr(III) with citrate ion. The CL technique when applied to kinetic studies has the advantage of being applicable in a variety of systems including those containing solid phases. No filtration is required, reducing the associated problems of contamination and adsorption and allowing studies to be made at environmentally reasonable concentrations of several trace elements. Currently the elemental species which can be studied using the CL technique at levels consistent with their natural concentrations include Cr(III), Co(II), and Fe(II). An important advantage of the CL technique is that the concentrations of only one species of an element can be monitored independently of the other forms of the element present. The combination of this technique for kinetic studies with equilibrium studies of simple systems of environmental relevance should lead to measurement of fundamental thermodynamic parameters and elucidation of the mechanisms of these reactions. (Moore-IVI)
W84-02741

INFLUENCE OF FLOW-RELATED EVENTS ON CONCENTRATION AND PHASE DISTRIBUTION OF METALS IN THE LOWER FRASER RIVER AND A SMALL TRIBUTARY STREAM IN BRITISH COLUMBIA, CANADA,
Victoria Univ. (British Columbia). Dept. of Biochemistry and Microbiology.
G. G. Geesey, L. Borstad, and P. M. Chapman.
Water Research, Vol. 18, No. 2, p 233-238, 1984. 3 Fig, 7 Tab, 20 Ref.

Descriptors: *Path of pollutants, *Heavy metals, *Flow, *Fraser River, *Still Creek, *British Columbia, Seasonal variation, Spring freshet, Copper, Nickel, Zinc, Sediments.

Spring freshet, an annual phenomenon in western Canada and the northwestern U.S., can substantially modify river and stream beds. Drainages are likely to mobilize considerable quantities of heavy metals which accumulate in bottom sediments of polluted regions during low flow periods. Samples of sediments were collected at three locations in order to study the effects of seasonal water flow variations on the concentrations of reactive and non-reactive copper, nickel, and zinc in surficial bottom deposits of the lower Fraser River and one of its more polluted tributaries, Still Creek. A substantial portion of the total copper, nickel and zinc in bottom sediments of the lower Fraser River and Still Creek were in reactive forms. Particulate rather than dissolved components were responsible for the bulk of the metal interactions within all of the sediments examined. Increased flow generally resulted in a loss of reactive copper, nickel and zinc from sediments of Still Creek and of reactive copper and zinc from sediments of the Fraser River. Decreased flow was accompanied by an increase in the levels of the reactive copper, nickel and zinc fractions in both systems. Flow-related processes appeared to influence concentration and phase distribution of the metals in these lotic environments. (Moore-IVI)
W84-02751

OBSERVATIONS ON THE CHEMICAL COMPOSITION OF RAIN USING SHORT SAMPLING TIMES DURING A SINGLE EVENT,
Hope Coll., Holland, MI. Dept. of Chemistry.
For primary bibliographic entry see Field 2K.
W84-02772

CADMIUM UPTAKE AND DISTRIBUTION IN STICKLEBACKS RELATED TO THE CONCENTRATION AND METHOD OF EXPOSURE,
University of Wales Inst. of Science and Technology, Cardiff. Dept. of Applied Biology.
J. Woodworth, and D. Pascoe.
Ecotoxicology and Environmental Safety, Vol. 7, No. 6, p 525-530, December, 1983. 1 Fig, 1 Tab, 17 Ref.

Descriptors: *Cadmium, *Path of pollutants, *Stickleback, Heavy metals, Absorption, Fish.

The uptake of cadmium by sticklebacks and its distribution between the body tissues was compared following two methods of exposure: natural exposure to the heavy metal in water, and direct intraperitoneal injection. Cadmium was detected in all organs examined with the highest levels occurring in the liver, gall bladder, kidney and spleen, respectively. The whole fish concentration factors showed a similar inverse relationship with exposure concentration to that recorded in previous studies. The levels in gut and gill were elevated following natural cadmium exposure, as expected as these organs could be major uptake sites of a poison from the water. Sticklebacks injected with about 5 micrograms Cd/g body weight retained about 60% of this dose 60 hours post-injection. The primary sites of retention were the liver, gall bladder, kidney and gut while the level in gills was rather low. (Baker-IVI)
W84-02777

THE ZONE OF FLOW ESTABLISHMENT FOR PLUMES WITH SIGNIFICANT BUOYANCY,
Salford Univ. (England). Dept. of Mathematics.
B. Henderson-Sellers.
Applied Mathematical Modelling, Vol. 7, p 395-398, December, 1983. 2 Fig, 1 Tab, 13 Ref.

Descriptors: *Plumes, *Buoyancy, Path of pollutants, Mathematical models, Flow establishment, Jets, Trajectory, Froude number.

In the problem of simulating plumes of water into lakes, of sewage into oceans or waste gases into the atmosphere, much work has been done by evaluating the trajectory characteristics by solution of sets of differential equations. The profile is assumed to be self-similar and Gaussian, a flow which is established approximately six stack diameters downstream. This is the zone of established flow (ZEF). In the short distance between the exit and the beginning of the ZEF (in the zone of flow establishment, ZFE), the flow develops from the 'top hat' profile at the source to the Gaussian profile at the beginning of the ZEF. The Gaussian profile, observed at the beginning of the ZEF, must be related to source 'top hat' parameter values. However, previously used formulae are approximations, being valid only for non-buoyant sources ('pure jets'). Extensions to sources of significant buoyancy are described in terms of the densimetric Froude number. (Moore-IVI)
W84-02781

THE ECOLOGY OF RUNNING WATERS NEAR ABERFELDY, SCOTLAND, IN RELATION TO A PROPOSED BARYTES MINE: AN IMPACT ASSESSMENT,
Institute of Terrestrial Ecology, Edinburgh (Scotland).
B. D. Smith, A. A. Lyle, and P. S. Maitland.
Environmental Pollution (Series A), Vol. 32, No. 4, p 269-306, 1983. 5 Fig, 12 Tab, 58 Ref.

Descriptors: *Mining, *Barytes, *Environmental effects, *Scotland, *Water pollution sources, Wastewater disposal, Heavy metals, Lead, Zinc, Monitoring, Stream pollution, Barite, Sediments.

A proposal to mine barytes (barium sulfate) near Aberfeldy, Scotland has led to concern over the possible ecological effects. Associated with the barium are several toxic metals, notably zinc and lead. Unless care is taken during the development, it is likely that these may find their way into the local freshwater systems, and so into the River Tay. Initially, three hill streams (Camserney, Cluny and Frenich Burns) and the River Tay were chosen for research on the hydrology, chemistry and biology of the waters in this area. The most notable result found was the biological impoverishment of the Frenich Burn; this was due either to the burn being naturally more metalliferous than the other waters or that it has been significantly affected by road works and preliminary mining activities. A fourth stream (Middleton Burn), whose catchment is also highly metalliferous but free from such activities, was subsequently surveyed. Human activities in the Frenich catchment are likely to be major contributory factors to its impoverishment. An assessment was made of the impact of this mining development on the ecology of the local waters. The most serious hazard was thought to be contamination by toxic metals. Additionally, road works, the establishment of the mine and associated activities all present potential problems. The three main potential problems are sedimentation (due both to construction activities and the crushing and removal of the relatively insoluble barytes), heavy metal pollution, and organic pollution. In order to reduce the impact of road and site works construction procedures should be such as to keep the erosion and wash-out of loose materials into streams to the minimum. To prevent heavy metal contamination, it may be necessary to treat the effluent before discharge. Careful selection of the discharge site is also essential. Tentative water quality standards are suggested. A monitoring program should be developed coincidentally with the mining development and maintained at least during the early years, if not through the entire life of the mine. (Moore-IVI)
W84-02788

MESOCOSM EXPERIMENTS TO DETERMINE THE FATE AND PERSISTENCE OF VOLATILE ORGANIC COMPOUNDS IN COASTAL SEAWATER,
Woods Hole Oceanographic Institution, MA. Dept. of Chemistry.
S. G. Wakeham, A. C. Davis, and J. L. Karas.
Environmental Science and Technology, Vol. 17, No. 10, p 611-617, 1983. 4 Fig, 2 Tab, 47 Ref. EPA grants R80607212 and CR807795.

Descriptors: *Coastal waters, *Fate of pollutants, *Persistence, *Organic compounds, *Volatile compounds, Hydrocarbons, Chlorinated hydrocarbons, Aliphatic hydrocarbons, Seawater, Estuarine enviroment, Biodegradation, Seasonal variation.

Studies were carried out in experimental marine ecosystems to determine the fate and persistence of a series of volatile organic compounds in coastal seawater. A suite of aliphatic hydrocarbons, aromatic hydrocarbons, chlorinated C2-hydrocarbons, and chlorinated aromatic hydrocarbons, covering a wide range of water solubilities, volatilities, and susceptibilities to biological degradation, was added to the water column of the mesocosms at

concentrations typical of a moderately polluted estuary (0.2-4 micro g/L). Concentrations in the water column were followed for up to 2 months, under experimental conditions simulating winter, spring, and summer. Water column half-lives of the same compounds ranged from about 1 day to up to 4 weeks, depending on season and compound class. Volatilization appears to be the major process removing aromatic hydrocarbons, chlorinated C2-hydrocarbons, and chlorinated aromatic hydrocarbons during all seasons, with biodegradation also important for aromatic hydrocarbons in summer. Aliphatic hydrocarbons are quickly sorbed onto particulate matter and thus removed from the 'volatile' pool; biodegradation also affects the alkanes. (Author's abstract)
W84-02790

BIODEGRADATION OF THE MONOCHLOROBIPHENYLS AND BIPHENYL IN RIVER WATER,
Dow Chemical Co., Midland, MI. Environmental Sciences Research Lab.
R. E. Bailey, S. J. Gonsior, and W. L. Rhinehart.
Environmental Science and Technology, Vol. 17, No. 10, p 617-620, October, 1983. 5 Fig, 1 Tab, 20 Ref.

Descriptors: *Biodegradation, *Biphenyls, *Monochlorobiphenyls, Mineralization, Degradation, Fate of pollutants, Polychlorinated biphenyls.

The rates of primary biodegradation, as well as mineralization, of the three isomers of monochlorobiphenyl (MCB), biphenyl (BP), and 2,2',4,4'-tetrachlorobiphenyl (TCB) have been determined by using a river water dieaway test. Analysis of river water extracts by high-performance liquid chromatography showed the times for 50% degradation of parent MCBs were 2-3 days and 1.5 days for BP at initial concentrations of about 1 micro g/L. The unchlorinated ring degraded initially and after a 50-day incubation, approximately 50% of the theoretical C-14 labeled CO2 was recovered from the subsequent degradation of the chlorinated ring of the MCBs. The rate of biodegradation of higher concentrations was somewhat slower. No degradation of TCB was observed over 98 days under conditions of this test. (Author's abstract)
W84-02791

SUBSURFACE ORGANIC CONTAMINANTS,
J. Josephson.
Environmental Science and Technology, Vol. 17, No. 11, p 518A-521A, November, 1983. 2 Fig, 1 Tab.

Descriptors: *Groundwater movement, *Path of pollutants, Leaching, Waste disposal, Trichloroethylene, Decomposing organic matter, Halogenated hydrocarbons, Humic substances, Soil chemistry.

One subsurface contaminants of particular concern is trichloroethylene (TCE). The fate and transport of contaminants such as TCE are thought to depend on the sorptive nature of the soils, the geochemical conditions that may control biological or chemical transformation, and hydrodynamic characteristics of the aquifer. Where conditions do not favor transformation, sorption of the contaminant by the soil may be the dominant process. The capacity of an organic compound to adsorb and the intensity of its adsorption vary directly with the octanol/water partition coefficient and inversely with its solubility in water. In a field investigation of halogenated organic solutes, injections of these substances were made into a relatively uncontaminated portion of an unconfined sand aquifer in Ontario, above an existing landfill leachate plume. Over 9000 samplings have been taken thus far in this experiment to study groundwater transport of contaminants. The possibility that humic substances in soil could affect the subsurface aqueous behavior of organic contaminants is also being examined. Other possible reactions to consider include the transformation of halogenated hydrocarbons into volatile organosulfur compounds and transformation or mineralization by microorganisms. (Baker-IVI)
W84-02792

FRESHWATER ACIDIFICATION FROM ATMOSPHERIC DEPOSITION OF SULFURIC ACID: A CONCEPTUAL MODEL,
Virginia Univ., Charlottesville. Dept. of Environmental Sciences.
J. N. Galloway, S. A. Norton, and M. R. Church.
Environmental Science and Technology, Vol. 17, No. 11, p 541A-545A, November, 1983. 2 Fig, 19 Ref.

Descriptors: *Acid rain, *Model studies, Sulfuric acid, Acidification, Natural waters, Conceptual models, Environmental effects, Ecosystems.

A simple conceptual model is presented that incorporates only a few key processes which are felt to determine how aquatic ecosystems respond to acid deposition with respect to time. The model is based on the assumption that if the rate of acid deposition changes, a variety of constituents in both the terrestrial and aquatic systems will respond. The model has seven stages: preacidification stage - steady state prior to significant emissions or anthropogenic sulfur; undersaturated sulfate adsorption capacity; saturated sulfate adsorption capacity in soil; steady-state period of lake acidification; supersaturated sulfate adsorption capacity; recovery of the percent base saturation; and the stable period of lake recovery. The model can be used by defining the pertinent characteristics of each stage and identifying geographical regions that have those characteristics. (Baker-IVI)
W84-02793

PREDICTION OF BUFFER CATALYSIS IN FIELD AND LABORATORY STUDIES OF POLLUTANT HYDROLYSIS REACTIONS,
Portland State Univ., OR. Dept. of Environmental Science and Chemistry.
E. M. Perdue, and N. L. Wolfe.
Environmental Science and Technology, Vol. 17, No. 11, p 635-642, November, 1983. 7 Fig, 4 Tab, 15 Ref.

Descriptors: *Pollutants, *Hydrolysis, *Buffers, *Catalysis, Fate of pollutants, Water pollution, Natural waters.

A mathematical model, based on application of the Bronsted equations for general acid-base catalysis, has been developed for use in forecasting the maximum contribution of buffer catalysis in pollutant hydrolysis reactions. The predictive capacity of the model is utilized to examine the potential significance of buffer catalysis in selected buffers and in a nutrient medium, both typical of laboratory studies, as well as in natural waters of varying chemical composition. Buffer catalysis is predicted to be potentially significant in laboratory studies that use buffers at concentrations above 0.001 M to maintain constant pH; however, at the very low concentrations of Bronsted acids and bases in most aquatic environments, this phenomenon is probably insignificant. (Author's abstract)
W84-02794

PESTICIDE CONCENTRATIONS AND YIELDS IN RUNOFF FROM SILTY SOILS IN THE LOWER MISSISSIPPI VALLEY,
Agricultural Research Service, Baton Rouge, LA.Soil and Water Pollution Research Unit.
G. H. Willis, L. L. McDowell, C. E. Murphree, L. M. Southwick, and S. Smith, Jr.
Journal of Agricultural and Food Chemistry, Vol. 31, No. 6, p 1171-1177, November-December, 1983. 12 Fig, 7 Tab, 17 Ref.

Descriptors: *Pesticides, *Runoff, *Sediment concentration, Storm runoff, DDT, DDE, Toxaphene, Trifluralin, Agricultural runoff, Nonpoint pollution sources, Tillage, Pesticide residues, Organic matter, Cotton, Mississippi Valley.

Toxaphene, DDT, DDE, trifluralin, and sediment concentrations in runoff from an 18.7-ha watershed, planted to continuous cotton (Gossypium hirsutum L.), were measured from 1973 through 1978 to determine pesticide and sediment yields. Storm pesticide yields for DDT, DDE, trifluralin, and toxaphene (in years when not applied) were linear functions of storm sediment yields. In 1974-1977 linear relationships between toxaphene and sediment yields were evident only when each year's data were examined according to periods of similar tillage and toxaphene application regimes. Annual pesticide yield was correlated with annual sediment yield only for DDT and DDE. In 1973-1978 clay concentration in runoff was a linear function of sediment concentration, bu sediment organic matter (OM) concentration was a nonlinear function of sediment concentration, due to OM enrichment at low sediment concentrations. In general, DDT and DDE concentrations in 1973-1978 and toxaphene concentration in 1973 and 1978 were linear functions of sediment OM concentration and of OM plus clay concentration but were nonlinear functions of sediment concentration. In years when toxaphene and trifluralin were applied (1974-1977 and 1973-1978, respectively) their concentrations did not correlate with sediment concentration. Except for DDE, mean annual pesticide concentration did not correlate well with mean annual sediment concentration. Soil residual pesticide concentration was not directly related to the amount applied each year. Wide ranging weather conditions probably caused variations in the relationship between loading rates and residual concentrations. (Moore-IVI)
W84-02795

OXIDATION DEGRADATION OF THE PISCICIDE SQUOXIN IN AERATED RIVER WATER,
North Carolina Agricultural and Technical State Univ., Greensboro. Dept. of Chemistry.
J. E. Oliver, C. N. Lamb, and R. H. Smith, Jr.
Journal of Agricultural and Food Chemistry, Vol. 31, No. 6, p 1178-1183, November-December, 1983. 7 Fig, 26 Ref.

Descriptors: *Organic compounds, *Oxidation, *Fate of pollutants, *Squoxin, Rivers, Piscicides, Chemical reactions.

Squoxin, a piscicide, rapidly decomposes in aerobic river water, but not in aerobic distilled water. The reaction has at least two requirements - oxygen and some component of river water. Oxidation of squoxin in river water, unlike its oxidation by most chemical agents, apparently produces an unstable hydroperoxide that fragments to 1,2-naphthoquinone and 1,2-naphthoquinone 1-methide. The former compound further decomposes to a number of other products whereas the latter compound instantly hydrates to form the relatively stable 1-(hydroxymethyl)-2-naphthol, which in turn decomposes producing formaldehyde and probably additional 1,2-naphthoquinone. (Baker-IVI)
W84-02796

LEAD LEVELS IN SNOW DUMPING SITES ALONG RIVERS IN DOWNTOWN WINNIPEG, MANITOBA, CANADA,
Winnipeg Univ. (Manitoba).
A. R. Lockery, T. Gavrailoff, and D. Hatcher.
Journal of Environmental Management, Vol. 17, No. 2, p 185-190, 1983. 4 Fig, 2 Tab, 7 Ref.

Descriptors: *Lead, *Snow removal, *Path of pollutants, *Winnipeg, *Manitoba, Assiniboine River, Red River, Snow dump, Sediments, Water pollution sources, Urban areas, Heavy metals.

Lead levels were determined in residual sediments from snow dumps in downtown Winnipeg. All samples taken within the dump sites showed significantly higher lead levels than the adjoining soils. There were also visible patterns and trends within the snow dump sediments which necessitate further interpretation. The Assiniboine dump site had not been used for dumping since the winter of 1976-1977, and yet it showed a much greater gradient between the low levels in the river and the dry zone than the Red River dump which continues is use. Both the Red River and the Assiniboine River have different flow regimes, but the findings indicate that over the period of one summer and fall the Red River sediments show a reduction of 83 mg/l or 32% while the smaller Assiniboine River shows a reduction of 205.3 mg/l in five years (71%) or 41 mg/liter in a year's time. There has been at both dumps no change in lead levels since

1974, indicating that the bond between lead and particulate matter is both strong and stable in the environment. Manitoba should consider adopting legislation to ban snow dumping within 150 ft of a waterway, as is the case in Ontario and Alberta. (Baker-IVI)
W84-02821

ASSESSMENT OF HUMAN EXPOSURE AND HEALTH RISK TO ENVIRONMENTAL CONTAMINANTS IN THE ATMOSPHERE AND WATER WITH SPECIAL REFERENCE TO CANCER,
National Cancer Inst., Bethesda, MD. Div. of Cancer Cause and Prevention.
H. F. Kraybill.
Journal of Environmental Science and Health, Vol. C1, No. 2, p 175-212, 1983. 17 Tab, 103 Ref.

Descriptors: *Water quality, *Public health, *Carcinogens, *Reviews, Drinking water, Radionuclides, Organic compounds, Inorganic compounds, Industrial waste, Agricultural practices, Pesticides, Water pollution sources.

Concern is currently high over contaminants of natural origin and those that are inadvertently added through man's lack of attention over the years to drinking water supplies. Materials of natural origin include asbestiform materials or asbestos particles, radioactive components (radionuclides), natural marine oil seepage which is a source of polycyclic aromatic hydrocarbons, and inorganic chemicals resulting from weathering of rocks, soil leaching or other processes. Another source of drinking water contaminants arises from agricultural practices. Some of this contamination occurs through direct dumping of these agricultural chemicals into waterways, some from municipal sewage effluents, and, in farming areas, by soil erosion and so-called agricultural runoff from heavy rains and flooded areas. Some contamination occurs from aerial drift and aerial spraying operations. Industrial pollution of water resources results from spills of chemicals or petroleum, emission of chemicals into the atmosphere such as vinyl chloride, and direct discharge of improperly treated wastes. The search for alternative energy sources has also resulted in some contamination. Geothermal technologies might place radionuclides as pollutants into the water. Use of fossil fuel, and in particular the advanced coal combustion technologies and extraction processes are expected to yield some problems. The effect of water processing or treatment on contamination is discussed. The frequency and geographic variations in the distribution of contaminants is considered and information is provided on the identification and classification of carcinogenic contaminants in types of water including drinking water. Some data on risk assessment is provided. (Baker-IVI)
W84-02823

APPLICATION OF A TIME-DEPENDENT DISPERSION MODEL FOR DISPERSION PREDICTION IN NATURAL STREAMS,
Hong Kong Univ. Dept. of Civil Engineering.
P. H. Lui, and A. W. Jayawardena.
Hydrological Sciences Journal, Vol. 28, No. 4, p 475-483, December, 1983. 2 Fig, 5 Tab, 12 Ref.

Descriptors: *Dispersion, *Mathematical models, Tracers, Fickian models, Langrangian correlation, Hong Kong, Tung Chung stream, Lam Tsuen River, Yuen Long Channel, Indus River.

A time-dependent dispersion model based on Lagrangian correlation and calibrated using laboratory data is applied to predict dispersion in four narrow streams in Hong Kong, the Tung Chung Stream, Lam Tsuen River, Yuen Long Channel and Indus river. Two types of tracers were used, sodium chloride in the Tung Chung Stream and Lam Tsuen River, and sulforhodamine B in the Indus River and Yuen Long Channel. For early stages of dispersion of modified Fickian model was used to predict the values of dispersion coefficient. For large times a value time of 10 must be estimated before predictions can be made, and in this study it was estimated by trial and error. Satisfactory predictions have been obtained for the test reaches considered. (Murphy-IVI)
W84-02826

A PROPOSED UPSTREAM WEIGHT NUMERICAL METHOD FOR SIMULATING POLLUTANT TRANSPORT IN GROUNDWATER,
Shandong Univ., Jinan (China). Dept. of Mathematics.
N.-Z. Sun, and W. W.-G. Yeh.
Water Resources Research, Vol. 19, No. 6, p 1489-1500, December, 1983. 16 Fig, 2 Tab, 26 Ref, 1 Append.

Descriptors: *Groundwater pollution, *Path of pollutants, Mathematical models, Convection, Dispersion.

Based upon the concept of upstream weighting and multiple cell balance, a new numerical method was developed for simulating the two-dimensional transport process in groundwater. General triangular elements are used, and the center of each element is taken as an invented node. The discretized system of the solute transport equations is derived from the integral form that expresses the balance of mass in each element. An upstream weight that depends on the local Peclet number is directly added to the basis functions. When convective transport dominates the dispersive transport, this technique can eliminate the oscillation of solutions efficiently, with only a nominal increase of computation effort over that of the general linear triangular Galerkin finite element method. The accuracy of the proposed numerical model is tested against two classical problems for which analytical solutions exist. The agreement is nearly exact. The instabilities of numerical solutions occur not only in the simulation of convective dominated flows but also in the simulation of a practical groundwater pollution process. The adaptive upstream weights are successful for both cases. (Moore-IVI)
W84-02852

POLLUTION ROUTING IN STREAMS,
Vanderbilt Univ., Nashville, TN. Dept. of Civil and Environmental Engineering.
A. D. Koussis, M. A. Saenz, and I. G. Tollis.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1636-1651, December, 1983. 2 Fig, 6 Tab, 18 Ref, 2 Append.

Descriptors: *Path of pollutants, *Dispersion, Mathematical models, Simulation, Stream pollution, Storage routing, Water quality.

A method for the numerical simulation of longitudinal dispersion of pollutants in streams is developed and tested. It is based on the one-dimensional, linear advection-dispersion equation and employs the concept of pseudo-viscosity to model the physical dispersion process. The numerical scheme is formally identical to a storage routing type scheme, and can provide the basis for an efficient computation of water quantity and water quality. The mathematical properties of this scheme are attractive; it is explicit, second-order-in-space accurate, and stable when used to model physical dispersion phenomena. The validity and reliability of the computations are investigated in three examples. These include an analytical test case, a laboratory test case, and a field test case, and deal with response prediction and parameter identification calculations. The method is capable of simulating the dispersion process reliably and with good accuracy. (Moore-IVI)
W84-02877

UNIFIED THEORY FOR FLOOD AND POLLUTION ROUTING,
Vanderbilt Univ., Nashville, TN. Dept. of Civil and Environmental Engineering.
A. D. Koussis.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1652-1664, December, 1983. 1 Tab, 12 Ref, 2 Append.

Descriptors: *Flood routing, *Path of pollutants, Mathematical models, Dispersion, Diffusion, Water quality, Flood waves, Concentration waves.

Environmental concerns have placed increased emphasis on the simultaneous consideration of quantity and quality aspects of water resources problems. Flood and pollution routing can be accomplished by the same numerical scheme, derived from the discretization of the purely advective transport equation through exploitation of the scheme's numerical dispersion properties to model the physical dispersion/diffusion behavior of the flow system. The one dimensional advection-diffusion/dispersion equation (A/D equation) is the standard transport model for many water quality computations. The same type of equation describes approximately, but with sufficient accuracy for most practical cases, the movement of flood waves in open channels. The linear diffusion wave model is equivalent to storage routing models with which it shares an extremely efficient computational structure that makes it an attractive engineering tool. The diffusion/dispersion routing schemes can be used to compute efficiently the propagation of flood waves and conservative constituent concentration waves in natural and artificial channels. (Moore-IVI)
W84-02878

ATTENUATION OF GROUND-WATER CONTAMINANT PULSES,
Illinois Univ. at Urbana-Champaign. Dept. of Civil Engineering.
A. J. Valocchi, and P. V. Roberts.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1665-1682, December, 1983. 13 Fig, 2 Tab, 21 Ref, 3 Append.

Descriptors: *Groundwater pollution, *Dispersion, *Path of pollutants, Wastewater injection, Organic compounds, Mathematical equations, Alluvial aquifers, Palo Alto Baylands.

Analytical solutions to the one-dimensional advection-dispersion equation are presented for several cases where the source concentration is either input continuously at a periodically fluctuating level or input as a single pulse of finite duration. The solute of interest can undergo linear equilibrium adsorption. Both semi-infinite and infinite flow domains are considered. The solutions are utilized to quantify the degree to which the traveling contaminant pulses are attenuated (damped) as they migrate through an aquifer. The degree of damping is shown to be related to two dimensionless parameters and this relationship is conveniently presented in graphical form. The analytical results compare favorably with the behavior of trace organic contaminant pulses observed during injection of advanced-treated wastewater into a shallow, alluvial aquifer in the Palo Alto Baylands. (Author's abstract)
W84-02879

SIDE DISCHARGES INTO OPEN CHANNELS: MATHEMATICAL MODEL,
Karlsruhe Univ. (Germany, F.R.). Sonderforschungsbereich 80.
For primary bibliographic entry see Field 8B.
W84-02880

SOURCES OF THE NITRATE IN PHREATIC GROUNDWATER IN THE WESTERN KALAHARI,
National Physical Research Lab., Pretoria (South Africa). Natural Isotopes Div.
T. H. E. Heaton.
Journal of Hydrology, Vol. 67, No. 1-4, p 249-259, 1984. 3 Fig, 1 Tab, 28 Ref.

Descriptors: *Nitrates, *Groundwater, Groundwater pollution, Agricultural wastes, Denitrification, Leaching, Deserts.

Elevated levels of nitrate occur in phreatic groundwater in the western Kalahari, Namibia. Nitrate in water containing 0.4-3.1 meq NO3/l, of widespread occurrence, has delta to the 15th power N values in the range +4.9 to +8.0%, suggesting natural derivation from the soil. The sporadic occurrence of very high levels of nitrate (>4 meq NO3/l), which has delta to the 15th power N

between +9.3 to +18.7%, reflects pollution derived from animal waste. It is important to consider the possible isotopic effects of denitrification, and to determine the significance of leaching in the nitrogen budget of the Kalahari soil. (Murphy-IVI)
W84-02896

TREND OF THE NITRATE AND AMMONIUM CONTENT OF PRECIPITATION WATER IN HUNGARY FOR THE LAST 80 YEARS,
Institute for Atmospheric Physics, Budapest (Hungary).
L. Horvath.
Tellus, Vol. 35B, No. 5, p 304-308, November, 1983. 4 Fig, 2 Tab, 11 Ref.

Descriptors: *Water pollution sources, *Nitrates, *Ammonium, *Precipitation, Hungary, Seasonal variation.

The seasonal variation of ammonium and nitrate concentrations in precipitation water in Hungary has changed markedly from the 1900s. Recently, characteristic spring maxima can be observed. These differences in the annual variations are not a consequency of the annual variation of the precipitation amount. In particular, the high ammonium concentrations in January and December, 1902, were accompanied by nearly the same monthly precipitation amounts as in 1979/81. One of the possible reasons for the differences in the annual variation of nitrate concentration may be the effect of increased human activity since the beginning of this century. The influence of increased anthropogenic emission in the annual variation of ammonium concentration cannot be excluded from consideration. (Baker-IVI)
W84-02915

WATER QUALITY AND THE DISCHARGE OF COOLING WATER INTO RIVERS, LAKES AND COASTAL WATERS,
Ente Nazionale per l'Energia Elettrica, Rome (Italy).
R. Gasparini.
Water Science Technology, Vol. 15, p 15-30, 1983. 31 Ref.

Descriptors: *Water quality, *Cooling water, *Discharge measurement, *Rivers, *Lakes, *Coastal waters, Ecological effects, Environmental effects, Reviews, Water pollution effects.

This paper resumes some of the main findings and conclusions of a study group on cooling water problems set up by UNIPEDE. The paper represents only the personal point of view of the author, in particular as chairman of the above mentioned group. The basic aim of the work was the study of the effects of the discharge of cooling water in the receiving water bodies (rivers, lakes and coastal waters). This type of assessment permits a more balanced and pragmatic approach to aspects such as thermal pollution, entrainment, impingement and pollution by antifouling agents. The first part of the paper deals with the problem of damage to organisms entering a cooling system. An important factor in assessing the meaning of such aspect is the growing evidence that there is no reduction in fish population of the receiving water body associated with the operation of modern power plants despite the catch in the once through-cooling systems due to entrainment and impingement, that can be minimized, but not avoided. The second part deals with the different methods of fouling prevention in power plants, with their possible environmental effects in the receiving water bodies. The third part is a comprehensible review of the results of aquatic impact studies at power plants, that is the results of many experimental investigations carried out in the field to evaluate the effects of the operation of once through cooling systems sited on rivers, lakes, or coastal waters. (Author's abstract)
W84-02934

DECOMPOSITION AND TRANSPORT OF MONOCHLORAMINE IN FRESH WATER,
Georgia Inst. of Tech., Atlanta. School of Civil Engineering.
Y-S. Lin, B. R. Kim, T. L. Bell, and R. J. Ruane.
Water Science and Technology, Vol. 15, p 215-226, 1983. 5 Fig, 1 Tab, 14 Ref.

Descriptors: *Decomposition, *Transport, *Monochloramine, *Fresh water, Aquatic life, First-order kinetics, Model studies, Chlorination, Chlorine residuals, Power plants.

Chlorinated effluents from cooling water condensers and wastewater treatment plants enter receiving streams and can affect aquatic organisms. The kinetics for dissipation of chlorine residuals (primarily monochloramine) in water under different light conditions (dark, sunlight, and UV light), by conducting a series of closed batch studies, was found to be first-order with respect to monochloramine concentration. This kinetic information was then incorporated into a two-dimensional transport model to describe concentration profiles in a river by considering the decay reaction, mixing, and dispersion, and by approximating the river as a straight rectangular channel. With chlorine residual persistence, chlorination at night could have more impact on aquatic life than during the day. (Murphy-IVI)
W84-02944

ANALYSIS OF EFFLUENTS AND RECEIVING WATERS ARISING FROM THE COAL FIRED KASIMPUR THERMAL POWER PLANT,
Aligarh Muslim Univ. (India). Environmental Research Lab.
M. Ajmal, A. A. Nomani, and M. A. Khan.
Water Science and Technology, Vol. 15, p 227-236, 1983. 1 Fig, 5 Tab, 19 Ref.

Descriptors: *Effluents,* Receiving waters, *Coal fired Thermal powerplant, *Kasimpur, Thermal powerplant, Ecological effects, Environmental effects, Metals, Cooling water, Chemical properties, Thermal pollution.

The waters of the upper Ganga canal, discharged cooling water and the machine washings of 530 MW Kasimpur coal fired thermal power plant were analysed for physico-chemical properties. The cooling effluent and washing downstream was richer in metal contents than upstream of the canal. The effects of influent and effluent water on the physico-chemical properties of soil, germination of seeds and growth pattern of the plants was insignificant. (Murphy-IVI)
W84-02945

ESTIMATED POLLUTION LOADINGS FROM NORWEGIAN FISH FARMS. II. INVESTIGATIONS 1980-1981,
Direktoratet for Jakt, Viltstell og Ferskvannsfiske, Aas (Norway).
A. Bergheim, H. Hustveit, A. Kittelsen, and A. R. Selmer-Olsen.
Aquaculture, Vol. 36, No. 1/2, p 157-168, January, 1984. 7 Fig, 1 Tab, 10 Ref.

Descriptors: *Aquaculture, *Water pollution sources, *Fish farming, Dissolved oxygen, Nitrogen, Nitrates, Phosphorus, Phosphates, Sodium, Potassium, Magnesium, Norway.

Pollution studies were carried out at a freshwater fish farm in 1980-81. The farm is situated near a fjord in the western part of Norway. Farming activity here is large, with both hatchery and many rearing units for salmonid fingerlings and brood fish. Two different investigations were carried out at the farm: a pollution loading registration during 24 hr in two farm sections, and a continuous registration of the water quality in the inlet/outlet of 37 fish tanks during 8 months. Several parameters were influenced markedly by the farming activity. Concentrations of total N increased by about 1000 micrograms/liter between the inlet and outlet. Increased phosphorus concentrations were also noted. Loading levels per unit of fish biomass were related to fish size. Loading/fish biomass decreased clearly with increasing fish weight. (Baker-IVI)
W84-02948

5C. Effects Of Pollution

CAROTENOID ENHANCEMENT AND ITS ROLE IN MAINTAINING BLUE-GREEN ALGAL (MICROCYSTIS AERUGINOSA) SURFACE BLOOMS,
North Carolina Univ. at Morehead City. Inst. of Marine Sciences.
H. W. Paerl, J. Tucker, and P. T. Bland.
Limnology and Oceanography, Vol. 28, No. 5, p 847-857, September, 1983. 6 Fig, 31 Ref. OWRT grant BNC-027 and NSF grant DEB 8104689.

Descriptors: *Eutrophication, *Microcystis, *Carotenoids, *Chlorophyll a, Cyanophyta, Photosynthesis, Ultraviolet radiation, Near-ultraviolet radiation, Photosynthetically active radiation.

Some blue-green algal genera can, through buoyancy alteration, accumulate in surface waters. An obvious advantage of such an accumulation is the ability to reside in a radiant energy-rich section of the water column, particularly in eutrophic or highly colored waters where photosynthetically active radiation is rapidly extinguished with depth. Despite the clear advantage of dominating surface waters, extensive residence in these waters also exposes algae to potentially harmful near-ultraviolet radiation. Photosynthetic pigment alteration by Microcystis aeruginosa in surface blooms was related to persistence and dominance by this blue-green alga. The progression of summer blooms coincided with rising carotenoid : chlorophyll a ratios. When analyzed by high performance liquid chromatography (HPLC), carotenoids exhibited strong in vitro absorbance in the UV and near-UV regions. Increased cellular carotenoid content was accompanied by increased surface photosynthesis as well as increased photosynthetic efficiencies in surface Microcystis populations. Radiant energy is most effectively utilized as a source of photoreducing power in the presence of elevated cellular carotenoid : chlorophyll a ratios of surface populations. Enhanced cellular carotenoid synthesis increases light utilization in the low and middle regions of the photosynthetically active radiation (PAR) spectrum and provides protection from UV damage. This has a positive effect on photosynthetic CO_2 fixation and bloom persistence in surface waters. (Moore-IVI)
W84-02484

NUTRIENT DYNAMICS IN SMALL MESOTROPHIC FENS SURROUNDED BY CULTIVATED LAND; I. PRODUCTIVITY AND NUTRIENT UPTAKE BY THE VEGETATION IN RELATION TO THE FLOW OF EUTROPHICATED GROUND WATER,
Utrecht Rijksuniversiteit (Netherlands). Dept. of Plant Ecology.
J. T. A. Verhoeven, S. van Beek, M. Dekker, and W. Storm.
Oecologia, Vol. 60, No. 1, p 25-33, 1983. 9 Fig, 3 Tab, 20 Ref.

Descriptors: *Fens, *Eutrophication, *Productivity, *Nutrients, Groundwater pollution, Water pollution effects, Groundwater movement, Nitrogen, Phosphorus, Potassium, Ammonia, Peat, Mineralization, Wetlands, Grasslands, Polders, Netherlands.

In a typical Dutch polder landscape the effects of nutrient transport from cultivated grassland to mesotrophic fen communities were studied. In a comparative approach, biomass production and nutrient (N, P and K) uptake were determined monthly in four fens and a hayfield differing in productivity and species composition. The interstitial ground water was sampled every two weeks for determinations of inorganic nutrient concentrations. The differences in productivity between the fens were clearly reflected in the amount of N, P and K taken up in the above-ground vegetation. N and P proved to be limiting plant growth in the fens, whereas K was the main limiting factor in the hayfield. The groundwater welling up from the sandy bottom into the fens proved to be rich in ammonia (3-5 ppm). There are strong indications that this continual seepage leads to a considerable

input of N into the fens but not to a higher productivity, as the ammonia is absorbed by the lowermost peat layers covering the sand. At this moment, the differences in productivity between the fens must be caused by differences in the rates of mineralization of the superficial peat layer. The degree of fixation of the floating vegetation mat, determining whether or not low water levels lead to an aerated soil top layer, is important in this respect. Within a period of decades, however, the continuous inflow of ammonia may eventually cause an increase in the productivity and a change in the species composition of the fens. (Author's abstract)
W84-02496

NUTRIENT GAIN FROM WET AND DRY ATMOSPHERIC DEPOSITION AND RAINFALL ACIDITY IN SOUTHERN CALIFORNIA CHAPARRAL,
San Diego Univ., CA. Dept. of Botany.
B. A. Ellis, J. R. Verfaillie, and J. Kummerow.
Oecologia, Vol. 60, No. 1, p 118-121, 1983. 3 Tab, 26 Ref. NSF grant DEB-8025977-0.

Descriptors: *Nutrients, *Precipitation, *Acid rain, *Chaparral, *California, Atmospheric deposition, Nitrogen, Calcium, Magnesium, Air pollution.

Ionic concentration and annual deposition of NO3(-)-N, NH4(+)-N, Ca(2+), and Mg(2+) from bulk precipitation and dry atmospheric deposition were studied for one year in southern California. Data were collected from an inland chaparral site at 1,300 m elevation, 75 km from the coast. The annual depositions of NO3(-)-N, and NH4(+)-N amounted to 96.3 and 56.0 mg/sq m ground area/yr, respectively. The corresponding values for calcium and magnesium ions were 207.4 and 57.4 mg/sq m/yr. The average pH of rainwater was 3.74 (range 3.37 to 4.75), thus documenting acid rain for an inland site in California, distant from urban sources of air contamination. An estimate of nitrogen gains and losses indicated that the time between recurrent chaparral fires should be about 60 years in order to maintain a balanced nitrogen budget. (Author's abstract)
W84-02497

LEAF LITTER DECOMPOSITION IN A RESERVOIR AFFECTED BY ACID MINE DRAINAGE,
Virginia Univ., Charlottesville. Dept. of Environmental Sciences.
J. Carpenter, W. E. Odum, and A. Mills.
Oikos, Vol. 41, No. 2, p 165-172, 1983. 2 Fig, 4 Tab, 28 Ref.

Descriptors: *Acid mine drainage, *Decomposition, *Litter, *Reservoirs, Water pollution effects, Leaves, Heterotrophs, Detritus, Microorganisms, Bacteria.

The effects of acid mine drainage on the decomposition of vascular plant material in a reservoir were compared at three sites: (1) a control site with no acid mine drainage (average pH = 6.3), (2) an experimental site with dilute acid mine drainage (average pH = 5.7) and (3) an experimental site near the acid mine drainage source (average pH = 3.7). The decomposition rate (loss of ash free dry weight from litter bags) of leaves from three types of trees and a rush differed significantly between leaf species and between sites. For all leaf species, the decay rate coefficients (k) for the control site were at least twice those for the most severely affected experimental site. Heterotrophic activity, measured with C-14 glucose, was depressed at both experimental sites as compared to the control site. Numbers of bacteria were about 10 to the 10th cells per gram dry detritus, and did not differ significantly between control and experimental sites. It was concluded that: (1) both microbial activity and the process of leaf decomposition were inhibited in a region close to the source of contamination although (2) the degree of inhibition decreased as the acid mine drainage was diluted within the reservoir. (Author's abstract)
W84-02498

DISCOVERING THE CAUSES, CONSEQUENCES, AND IMPLICATIONS OF ACID RAIN AND ATMOSPHERIC DEPOSITION,
North Carolina State Univ. at Raleigh. School of Forest Resources.
E. B. Cowling.
Tappi Journal, Vol. 66, No. 9, p 43-46, September, 1983. 2 Fig, 14 Ref.

Descriptors: *Acid rain, *Forestry, *Environmental effects, Lakes, Streams, Fish kills, Sulfuric acid, Nitric acid, Ozone, Distribution, Soil contamination, Plants, Nutrients, Water quality.

Areas receiving high acidic precipitation, average annual pH between 4.1 and 4.6 include many regions in which surface waters and aquatic life are sensitive to or are presently being affected by acid precipitation. The release of pollutants in meltwater during warm periods in winter or in early spring can cause dramatic consequences of acid input into aquatic ecosystems. In certain industrial regions of the world substantial damage to forests and crops is caused by dry deposition of toxic gases. Ozone, sulfur dioxide, oxides of nitrogen, fluoride, and hydrogen chloride are some of the worst offenders. The consequences of acid inputs to soils vary greatly, depending on the rates and recent history of atmospheric acid inputs, the character of the vegetation, natural rates of acid formation in the soil, and the physical/chemical properties of the soil. Acid precipitation increases the solubility and mobility of many cations in the soil. This increases the concentration of toxic metal cations, including potassium, aluminum, manganese, and zinc in the soil solution. It also increases the leaching of nutrient cations, including calcium and magnesium. These toxic and nutrient ions are transferred from soils into surface waters and groundwaters. Certain aspects of the acid precipitation problem are still not well understood and additional work is needed to develop possible solutions to the question. (Baker-IVI)
W84-02521

ACUTE TOXICITY AND BIOACCUMULATION OF LINDANE IN GUDGEON, GOBIO GOBIO (L.),
Liege Univ. (Belgium). Zoology Inst.
C. Marcelle, and J. P. Thome.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 4, p 453-458, October, 1983. 3 Fig, 1 Tab, 11 Ref.

Descriptors: *Lindane, *Fish, *Toxicity, *Bioaccumulation, *Gudgeon, Insecticides, Organochlorine pesticides, Organic compounds.

Acute toxicity tests were conducted with lindane on gudgeons to determine a LC50 (96 hr). Lindane contents in muscles, brain and liver were measured and factors of bioaccumulation of lindane were calculated. Lindane contents as measured in these tissues increased with lindane concentrations in water. This increase was relatively moderate until the 28.5 ppb level of lindane concentration in water was reached. Beyond this concentration, lindane concentration in liver and brain rose more sharply. Lindane concentration of 28.5 ppb in water was a threshold beyond which the accumulation of lindane in tissues and organs induced an increase in mortality. Bioaccumulation dramatically decreased between 0.22 and 28.5 ppb of lindane in water but increased beyond this threshold concentration. A very highly significant linear correlation was found between both variables in the case of brain and a very highly signficant logarithmic correlation in the cases of liver and muscles. The decimal lindane concentrations in brain exponentially increased with lindane concentrations in water. The brain appeared to accumulate lindane at a slower rate than liver and muscles when the lindane concentrations in water were low. This does not hold at concentrations above 30 ppb. A new method for extracting lindane from water is described. (Baker-IVI)
W84-02533

EFFECTS OF WATER HARDNESS, WATER TEMPERATURE, AND SIZE OF THE TEST ORGANISM ON THE SUSCEPTIBILITY OF THE FRESHWATER SHRIMP, GAMMARUS PULEX (L.), TO TOXICANTS,
Shell Research Ltd., Sittingbourne (England). Sittingbourne Research Centre.
R. R. Stephenson.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 4, p 459-466, October, 1983. 1 Fig, 3 Tab, 21 Ref.

Descriptors: *Shrimp, *Water pollution effects, *Toxicity, *Water temperature, *Water hardness, Size, Hardness, Chemical properties, Phenol, Copper, Lindane, Diethylhexyl phthalate.

The effects of water hardness, water temperature, size of test organism and duration of exposure on the acute toxicity of four substances to Gammarus pulex, the freshwater shrimp were investigated. The four test substances were phenol, copper (as cupric chloride), gamma-hexachlorocyclohexane (lindane), and di-ethylhexyl phthalate (DEHP). The influence of the three variables, water hardness, water temperature and size of organism, on the acute lethal toxicity of the four test materials to G. pulex was generally small. Only water hardness had statistically significant effects of LC50 values, and then only for copper and gamma-HCH when exposure periods were 48 hr or greater. Copper was some 4 to 6 times more toxic in soft water than in hard, whereas gamma-HCH was 1.5 to 2.5 times more toxic in hard water than in soft. Guidelines for acute lethality tests with G. pulex should recommend that tests be carried out in hard water, at 15 degrees C, with large specimens and that the exposure period should be 96 hr without a period of post-exposure observation. Large specimens are more easily observed and handled. (Baker-IVI)
W84-02534

EFFECTS OF ENVIRONMENTAL PH AND TEMPERATURE ON EMBRYONIC SURVIVAL CAPACITY AND METABOLIC RATES IN THE SMALLMOUTH SALAMANDER, AMBYSTOMA TEXANUM,
Tampa Univ., FL. Dept. of Biology.
F. Punzo.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 4, p 467-473, October, 1983. 2 Tab, 17 Ref.

Descriptors: *Salamanders, *Temperature effects, *Hydrogen ion concentration, Acidity, Water pollution effects, Water temperature, Hatching, Embryonic development, Oxygen consumption, Larvae.

Eggs and larvae of Ambystoma texanum were used in the study. Embryonic development was unsuccessful at 5 C and 30 C regardless of environmental pH. The optimum hatching success at all pH regimes occurred at 15 C for this species. Moderate hatching success (50 to 89%) was observed between 10 and 20 C within a pH range of 6 to 10. Optimal conditions included a pH range of 6 to 8. The most pronounced detrimental effects of pH on embryonic survival capacity were found at pH 4 to 5 and pH 11 over the temperature range of 10 to 25 C. The highest rate of oxygen consumption was at pH 6.6 for all developmental stages. Significant differences were found between oxygen consumption rates of fertilized eggs observed at pH 4 and 5 for the dorsal lip, late gastrula and neural plate developmental stages. Mortality in this species can be expected to increase markedly when the pH of pond water falls below 6.0 or exceeds 10.0. (Baker-IVI)
W84-02535

EFFECT OF THE AQUATIC HERBICIDE ENDOTHAL ON THE CRITICAL THERMAL MAXIMUM OF RED SHINER, NOTROPIS LUTRENSIS,
North Texas State Univ., Denton. Dept. of Biological Sciences.
J. C. C. Takle, T. L. Beitinger, and K. L. Dickson.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 5, p 512-517, November, 1983. 3 Tab, 27 Ref.

Descriptors: *Herbicides, *Weed control, *Fish, *Endothal, Toxicity, Shiners, Pesticides, Water temperature.

Red shiners were exposed to endothal for 48 hr. Endothol, as Aquathol-K did not significantly alter the critical thermal maximum (CTM) of Notropis lutrensis at the concentrations of 1 mg/L and 30 mg/L acid equivalence. These are the concentrations recommended for weed control. The mean CTM of 36.0 C for red shiner from these studies is slightly lower than reported values of 38.99, 37.8 and 38.0 C. Since endothal is usually degraded within one to five days by microbial activity, it has low persistence in aquatic environments. Even at concentrations 6 times the maximum recommended for aquatic use, endothal did not reduce the ability of red shiners to resist high temperatures. (Baker-IVI)
W84-02536

EFFECTS OF TEMPERATURE ON BEHAVIOR, GROWTH, DEVELOPMENT AND SURVIVAL IN YOUNG MILKFISH, CHANOS CHANOS (FORSKAL),
Southeast Asian Fisheries Development Center, Iloilo (Philippines). Aquaculture Dept.
A. C. Villaluz, and A. Unggui.
Aquaculture, Vol. 35, No. 4, p 321-330, December, 1983. 3 Fig, 3 Tab, 15 Ref.

Descriptors: *Milkfish, *Water temperature, *Growth, *Fish behavior, Feeding, Dissolved oxygen, Development.

Effects of three temperature treatments on activity, feeding, growth, development and survival of young milkfish (Chanos chanos) were investigated. Low temperature (<22.6 C) and hypoxial condition (<1 ppm O2) decreased activity, responsiveness and food intake; high temperature (up to 33 C) had the opposite effect. Growth and development were fastest in fish maintained in high temperature ($\bar{x}$ = 29.5 C). Fish in low temperature ($\bar{x}$ = 20.7 C) had the least growth and were inhibited from developing into juveniles during the 3-month period. Highest survival ($\bar{x}$ = 99.7%) was obtained in high temperature but was not significantly different ($P>0.05$) from ambient temperature ($\bar{x}$ = 97.7%). (Author's abstract)
W84-02540

POPULATION DYNAMICS OF CAULOBACTERS IN A MESOTROPHIC IRRIGATION POND,
Tsukuba Univ., Ibaraki (Japan). Inst. of Biological Sciences.
For primary bibliographic entry see Field 2H.
W84-02548

THE GRAM-STAIN CHARACTERISTICS OF THE BACTERIAL COMMUNITY AS A FUNCTION OF THE DYNAMICS OF ORGANIC DEBRIS IN A MESOTROPHIC IRRIGATION POND,
Tsukuba Univ., Ibaraki (Japan). Inst. of Biological Sciences.
For primary bibliographic entry see Field 2H.
W84-02549

PREDICTIVE CAPABILITY OF U.S. OECD PHOSPHORUS LOADING - EUTROPHICATION RESPONSE MODELS,
Texas Tech Univ., Lubbock. Dept. of Civil Engineering.
W. Rast, R. A. Jones, and G. F. Lee.
Journal of the Water Pollution Control Federation, Vol. 55, No. 7, p 990-1003, July, 1983. 4 Fig, 3 Tab, 57 Ref.

Descriptors: *Eutrophication, *Model studies, *Phosphorus, Nutrients, Water quality control, Water management, Mathematical models, Algae, Aquatic plants.

Two basic types of mathematical models have been developed for eutrophication modeling: statistical and dynamic models. Dynamic models consist basically of a series of interrelated differential equations which attempt to describe the biological, chemical, and physical reactions and interactions governing aquatic plant growth. A statistical eutrophication model is basically a statistical regression that quantifies a basic cause-and-effect relationship and does not attempt to account for or characterize every component involved in the eutrophication process. The predictive capability of the US Organization for Economic Cooperation and Development (OECD) eutrophication modeling approach regressions was examined by comparing the predicted and measured responses of water bodies subjected to substantial changes in their phosphorus loads. Certain conditions should be met before this model is applied to any water body. A principal prerequisite is that maximum summer algal biomass in the water body be limited by phosphorus. Another is that aquatic plant growth be manifested primarily as planktonic algae, rather than as attached algae or aquatic macrophytes. The water bodies must behave like completely mixed reactors; that they have constant volumes; and that P sedimentation is proportional to in-lake concentration. Implications of phosphorus loading eutrophication models for eutrophication management in water bodies are discussed. (Baker-IVI)
W84-02562

SURVIVAL INCIDENCE OF ANTIBIOTIC-RESISTANT COLIFORMS IN A LAGOON SYSTEM,
Biospherics, Inc., Rockville, MD.
A. J. Kish, and J. R. Lampky.
Journal of the Water Pollution Control Federation, Vol. 55, No. 5, p 506-512, May, 1983. 1 Fig, 7 Tab, 26 Ref.

Descriptors: *Coliforms, *Wastewater lagoons, Antibiotic resistance, Bacteria, Public health, Human pathology, Wastewater treatment, Freezing, Eutrophication.

The survival incidence of coliform bacteria resistant to five different antibiotics in a lagoon system that freezes during the winter was investigated. Some of the resistant species were identified. The percentage of resistant coliforms in the lagoon discharge and receiving creek were quantified and tests were performed for transmissable drug resistance in the discharged coliforms. The average number of total coliforms in all ponds rose during each of the last four sampling dates, but the percentage that were drug-resistant continued to decrease. This rise in total coliforms was perhaps due to increases in lagoon water depth, and therefore, decreases in ultraviolet light penetration, warming of the water, breakage of the ice pack and aeration, and the subsequent unicellular algal bloom witnessed in the early spring. The reason for the continued percentage decrease of drug-resistant coliforms is not clear. It is not clear why discharged coliforms resistant to cephalothin and ampicillin showed a large increase in incidence compared with the in-lagoon corresponding percentages for roughly the same time period. When resistance to one antibiotic is transferred, resistance to several other antibiotics is also conferred, though this was not tested, specifically. Even though over half of the tested strains could transfer tetracycline resistance to sensitive strains in the laboratory, probably a very low percentage could actually perform this transfer in the wild because turbulent conditions would easily break apart conjugation bridges. (Baker-IVI)
W84-02568

BIOASSAY EVALUATION OF DIVERSITY AND COMMUNITY COMPARISON INDEXES,
Alabama Univ. in Birmingham. School of Public Health.
J. L. Perkins.
Journal of the Water Pollution Control Federation, Vol. 55, No. 5, p 522-530, May, 1983. 4 Fig, 3 Tab, 22 Ref.

Descriptors: *Aquatic life, *Bioassay, Dissolved oxygen, Copper, Acidity, Water temperature, Specific conductivity, Benthic environment, Ecosystems.

The following community comparison or similarity indexes and diversity indexes were evaluated: Gleason's, Margalef's, Menhinik's, Simpson's, McIntosh's, Brillouin's, Shannon's, Shannon's approximate, Pielou's evenness, Margalef's redundancy, equitability, Jaccard's coefficient, Sokal and Michener's, Sorensen's coefficient, percentage similarity, coefficient of biosimilarity, distance, Bray-Curtis, Morisita's index, and Horn's index. Evaluation was made using a controlled community bioassay approach. If communities are constructed in which all environmental variables are equivalent, then impact caused by some added pollutant can be assessed and compared to a control community. Response of a community of benthic macroinvertebrates to geometric increases in copper concentration was measured. Shannon's index cannot be used alone. Community comparison indexes can be used to indicate even slight impact with come confidence. Shannon's index may give an indication of no impact or enrichment, when in fact there is some impact. The community comparison indexes do hold the possibility that as a group they can accurately address the issue of magnitude of impact on the community. Because all the indexes used ranged from zero to one, absolute changes in community similarity may be such that they can be grouped into high, medium, and low impact categories. (Baker-IVI)
W84-02570

EFFECTS OF AMMONIA AND CHLORINE ON FISH IN STREAMS RECEIVING SECONDARY DISCHARGES,
Southern Illinois Univ. at Carbondale. Fisheries Research Lab.
M. H. Paller, W. M. Lewis, R. C. Heidinger, and L. J. Wawronowicz.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1087-1097, August, 1983. 4 Fig, 7 Tab, 13 Ref.

Descriptors: *Fish populations, *Water pollution effects, *Chlorination, Wastewater treatment facilities, Secondary wastewater treatment, Chlorine, Ammonia, Turbidity, Illinois, Copper Slough, Kaskaskia Ditch, Saline Branch, Stream pollution.

Three streams receiving chlorinated secondary wastewater were monitored for about 1 year's time. Chlorination was then terminated but monitoring continued with particular reference given to changes that might have occurred in the fish communities when only ammonia was present without the chlorine. Samples were taken above and below the wastewater outfalls, on Copper Slough (receiving secondary wastewater of wholly domestic origin from the Champaign-Urbana Southwest Sewage Treatment Plant), Kaskaskia Ditch (receiving secondary wastewater from Copper Slough, its tributary), and Saline Branch, (receiving secondary wastewater from the Champaign-Urbana Northeast Plant, 81% domestic and 19% soybean and dairy processing waste). Total residual chlorine concentrations were generally highest at the first station below the wastewater outfall, and declined progressively at stations located further downstream. Total ammonia-N concentrations below the outfalls were much higher than total ammonia-N concentrations above the outfalls in all streams. Ammonia-N concentrations were fairly similar before and after chlorination was discontinued in Copper Slough and Kaskaskia Ditch. In contrast, ammonia-N concentrations in Saline Branch were higher after chlorination was discontinued, largely due to operational problems associated with the renovation of the sewage treatment plant. Turbidity was either greater above the outfall than below or quantitatively similar in both areas. However, wastewater associated turbidity below the outfall was qualitatively different from ambient turbidity above the outfall, as it consisted largely of sludge like materials, rather than silt or algae. The fish community in Copper Slough improved dramatically after chlorination was discontinued. Similar findings are reported for Kaskaskia Ditch, but not for Saline Branch, indicating that residual chlorine was not the only limiting factor in the effluent from the Northeast Treatment Plant. (Baker-IVI)
W84-02576

EFFECT OF EFFLUENT DISINFECTION ON RISKS OF VIRAL DISEASE TRANSMISSION VIA RECREATIONAL WATER EXPOSURE,
Illinois Inst. of Tech., Chicago. Pritzker Dept. of Environmental Engineering.
C. N. Haas.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1111-1116, August, 1983. 4 Tab, 34 Ref.

Descriptors: *Recreation, *Viruses, *Disinfection, *Effluents, *Disease transmission, Water treatment, Water quality control, Human diseases, Illinois, Water quality standards.

The assertion of minimal risk associated with the relaxation of fecal coliform standards and, implicitly, with wastewater disinfection is questioned. Evaluation of available data seems to show that the cessation of wastewater disinfection in Illinois may result in up to 2700 excess cases of viral disease per year because of recreational exposure. This risk, which on an absolute basis is not insignificant, when averaged over the entire state population is sufficiently low as to preclude facile detection. To develop a more precise estimate of the risk, one must give particular attention to obtaining data on viral decay, the specific numbers of recreational users at each stream site, and the probability that ingestion of an organism will result in disease. A general approach is outlined which should be suitable for analysis of specific stream locations, or the estimation of risk evaluation caused by recreationally contracted viral disease in other localities. (Baker-IVI)
W84-02579

A MARINE RECREATIONAL WATER QUALITY CRITERION CONSISTENT WITH INDICATOR CONCEPTS AND RISK ANALYSIS,
For primary bibliographic entry see Field 5A.
W84-02600

ANALYSIS OF 2,2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN IN GREAT LAKES FISH,
New York State Dept. of Health, Albany. Div. of Labs. and Research.
P. O'Keefe, C. Meyer, D. Hilker, K. Aldous, and B. Jelus-Tyror.
Chemosphere, Vol. 12, No. 3, p 325-332, 1983. 2 Tab, 22 Ref.

Descriptors: *Fish, *Water pollution effects, *Trichlorophenols, TCDD, Phenols, Tetrachlorodibenzo-p-dioxin, Great Lakes, Lake Ontario, Lake Huron, Water pollution sources.

Fish samples were taken from Lake Ontario and Lake Huron and analyzed for content of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Concentrations ranging from 2 to 162 pg/g (ppt) and from 2.5 to 20 ppt were found in the two lakes, respectively. Fish from other of the Great Lakes generally had no detectable signals for TCDD although a few samples had concentrations less than 3 ppt. One of the sampled areas, Cayuga Creek, enters the Niagara River and is connected to a storm sewer in the vicinity of the Love Canal, Niagara Falls, a former waste disposal site which received a variety of chemical wastes, including trichlorophenol wastes. While there are no manufacturing facilities for trichlorophenols on the peripheries of Lake Erie, Lake Michigan, or Lake Superior, certain parts of these lakes are undoubtedly exposed to significant quantities of fly ash, an alternative source of TCDD. (Baker-IVI)
W84-02622

THE IMPACT ON THE ECOLOGY OF POLYCHLORINATED PHENOLS AND OTHER ORGANICS DUMPED AT THE BANK OF A SMALL MARINE INLET,
Vandkvalitetsinstitutet, Hoersholm (Denmark).
J. Folke, J. Birklund, A. K. Sorensen, and U. Lund.
Chemosphere, Vol. 12, No. 9/10, p 1169-1181, 1983. 4 Fig, 2 Tab, 38 Ref.

Descriptors: *Water pollution effects, *Pentachlorophenol, *Tetrachlorophenol, *Waste dumps, Leachates, Organic compounds, Mussels, Sediments, Marine environment, Effluents, Marine animals, Holbaek Fjord, Denmark.

Municipal waste was dumped at the bank of a small marine inlet, the Holbaek Fjord (Denmark), during the period from 1953 to 1971 together with unknown amounts of chemical wastes. Leachate samples from the dump were shown to contain a number of organics, whereof pentachlorophenol (PCP) and 2,3,4,6-tetrachlorophenol (TeCP) constituted the greatest potential risk in relation to amounts and toxicity. PCP and TeCP were quantified in mussels (Mytilus edulis) stocked in growth cages, marine sediments, sea water, and in the secondary effluent of a nearby sewage treatment plant. The condition of the natural fauna was examined in terms of species composition, species density, and species diversity. The levels of PCP and TeCP were only slightly increased as compared to a reference area, and no acute toxic effects were detected. The present impact of the dump on the marine ecosystem based on the PCP burden is a factor of 1000 lower than the estimated effect level. It is recommended that the situation be monitored until it is evident that the leaching of organics from the dump has maximized and is declining. (Moore-IVI)
W84-02629

THE IDENTIFICATION AND EVALUATION OF BENTHIC MACROINVERTEBRATE ASSEMBLAGES IN AN INDUSTRIALISED ESTUARY-SOUTHAMPTON WATER, UK, USING A LONG-TERM, LOW-LEVEL SAMPLING STRATEGY,
Southern Water Authority, Otterbourne (England). Resources Planning Lab.
M. Houston, D. Lowthion, and P. G. Soulsby.
Marine Environmental Research, Vol. 10, No. 4, p 189-207, 1983. 6 Fig, 2 Tab, 19 Ref.

Descriptors: *Invertebrates, *Sampling, *Southampton Water, *England, *Estuarine environment, Water pollution effects, Benthos, Temporal distribution, Spatial distribution, Industrial wastewater, Species diversity.

Southampton Water is a shallow, linear body of water approximately 10 km long and 2 km wide. A narrow shipping channel is dredged to maintain a depth of 10 m below Chart Datum and is bordered by shallow water and some extensive intertidal mudflats. A long-term, low-intensity sampling strategy has been applied to the benthic infauna of Southampton Water to determine patterns of faunal distribution in relation to water quality influences. The estuary receives domestic and industrial discharges including a large oil refinery and associated petro-chemical industries. The faunal data from all the sites examined demonstrates a low species richness, low diversity and frequent numerical domination by a few species, suggesting the fauna is physically accommodated and provides a complex background against which to measure the effects of polluting effluents. The sites have been faunistically divided into three groups. Group I sites indicate an area of gross pollution. Group II sites are situated above and below the affected zone supporting a more diverse fauna. Group II and III sites both show a low species richness typical of a stressed, physically accommodated fauna. Spatial and temporal variations emphasize the need for a long-term approach to demonstrate the dominant faunal patterns in an area receiving a variety of discharges. The approach is economic in use of resources but compatible with the objectives of monitoring surveys. (Moore-IVI)
W84-02694

COMPARISONS OF TROPHIC STATE MEASUREMENTS,
Environmental Monitoring Systems Lab., Las Vegas, NV.
For primary bibliographic entry see Field 2H.
W84-02709

COMPLEXATION OF COPPER IN THE EFFLUENT OF A SEWAGE TREATMENT PLANT AND AN ESTIMATE OF ITS INFLUENCE ON TOXICITY TO COHO SALMON,
Seattle Metro Water Quality Lab., WA.
J. A. Buckley.
Water Research, Vol. 17, No. 12, p 1929-1934, 1983. 2 Fig, 4 Tab, 30 Ref.

Descriptors: *Copper, *Effluents, *Toxicity, *Salmon, Water pollution effects, Copper compounds, Organic compounds, Wastewater treatment, Trace metals, Complexation.

Measurements by cupric ion electrode of the complexing capacity of the effluent from a sewage treatment plant (STPE) averaged 0.300 mg/l. Of the complexed Cu 67% was due to compounds of < or = 10,000 MW. Organic compounds removable by activated carbon composed 88% of the total organic carbon and were responsible for 87% of the complexation. Complexation of Cu(2+) by STPE diminishes the toxicity from total Cu to juvenile coho salmon; the LC50 was 0.164 mg/l for river water vs 0.286 mg/l for 40% STPE. The LC50 of Cu(2+) was approximately the same (0.017 vs 0.022 mg/l) in both matrices; this species thus appears to play a toxic role. The mean survival time in diluted STPE with added Cu was inversely proportional to the Cu(2+) concentration. (Author's abstract)
W84-02734

EVALUATION OF AN APPLICATION FACTOR FOR DETERMINING THE SAFE CONCENTRATION OF AGRICULTURAL AND INDUSTRIAL CHEMICALS,
D.A.V. Coll., Muzaffarnager (India). Dept. of Zoology.
S. R. Verma, I. P. Tonk, A. K. Gupta, and M. Saxena.
Water Research, Vol. 18, No. 1, p 111-115, 1984. 4 Tab, 32 Ref.

Descriptors: *Application factor, *Toxicity, *Fish, Pesticides, Phenols, Heavy metals, Detergents, Agricultural chemicals, Larvae, Water pollution effects, Water quality standards.

An Application Factor can be defined as a decimal fraction of TL50 or a toxic unit acceptable as a reasonable estimate of a safe concentration in nature. The Application Factor of a toxicant experimentally determined for one species of fish may be applicable to other fish species. The Application Factors for a number of chemicals used in industrial and agricultural operations were evaluated by determining 96 h LC50 and maximum allowable toxicant concentration (MATC) using larvae and early juveniles of Cirrhina mrigala. The chemicals used were thiotox, aldrin, chlordane, lindane, benzene hexachloride (organochlorine pesticides); malathion, metasystox, dichlorvos, thiometon, abate (organophosphate pesticides); carbofuran, sevin (carbamate pesticides); phenol, 2,4-dinitrophenol, pentachlorophenol (phenolic compounds); copper sulfate, cadmium chloride, zinc sulfate, mercuric chloride (heavy metals) and swascofix P14, swanic 6L, swascol 3L, swascol 4L (synthetic detergent). Application factors for these chemicals range between 0.036 and 0.079. The values of Application Factor for most of the chemicals remained within the limited range, in spite of a wide range in their MATC. The use of an Application Factor provides an alternative to the cumbersome life cycle toxicity test. It also paves the way for an easy determination of a safe concentration irrespective of the water characteristics and organism involved, by multiplying the larval LC50 by the Application Factor. (Moore-IVI)
W84-02742

BACTERIAL QUALITY OF TILE DRAINAGE WATER FROM MANURED AND FERTILIZED CROPLAND,
Department of Agriculture, Ottawa (Ontario).
N. K. Patni, R. Toxopeus, A. D. Tennant, and F. R. Hore.
Water Research, Vol. 18, No. 2, p 127-132, 1984. 6 Tab, 15 Ref.

Descriptors: *Drainage water, *Bacteria, *Tile drainage, *Manure, *Fertilizers, Coliforms, Strep-

tococci, Water pollution sources, Groundwater pollution, Precipitation, Soil texture, Ontario.

Bacterial contamination of tile drainage water in three manured and one non- manured cropped fields was studied over a 4-year period at a large, mixed farm near Ottawa, Ontario, Canada. Concentrations of total coliforms, fecal coliforms (FC), fecal streptococci (FS) and Standard Plate Counts at 20 and 35 C, in both the drainage water and the applied dairy cattle liquid manure varied over a wide range. Bacterial concentrations in long-term winter-stored manure were much lower than in relatively fresh manure. Concentrations of FC and FS in the drainage water from the manured fields were lower than concentrations in the applied manure by 3-5 orders of magnitude. Bacterial concentrations in drainage water from all fields had low geometric mean and median values for all parameters tested. Water quality was satisfactory most of the time for recreational use or for use as a raw water source for drinking water supplies. Factors such as precipitation appeared to have a greater influence on drainage water quality than manure application. Influence of soil type on bacterial concentrations in drainage water from the manured fields was not evident. However, a lower unit-area tile outflow in coarse-textured soil compared to fine-textured soil indicated a greater potential in the former for fecal bacteria reaching groundwater beneath the tile drains. (Author's abstract)
W84-02743

COMPARATIVE STUDIES ON ECOTOXICOLOGY OF SYNTHETIC DETERGENTS,
Industrial Toxicology Research Centre, Lucknow (India).
H. Lal, V. Misra, P. N. Viswanathan, and C. R. Krishna Murti.
Ecotoxicology and Environmental Safety, Vol. 7, No. 6, p 538-545, December, 1983. 6 Fig, 2 Tab, 23 Ref.

Descriptors: *Detergents, *Toxicity, Alkyl benzene sulfonate, Daphnia, Mosquitos, Tubifex, Snails, Tadpoles, Fish, Larvae, Behavior, Ecosystems.

To predict the comparative toxicological response of synthetic detergents on aquatic ecosystems, the effects of various concentrations of neutralized alkyl benzene sulfonate were studied. The median tolerance limit at 48 hr, 95% confidence limit, slope function, presumable harmless concentration, and rate of survival of different species of aquatic fauna such as water fleas (Daphnia magna), mosquito larvae (Culex pipiens), slug worms (Tubifex rivulorum), snails (Lymnaea vulgaris), tadpoles (Rana cyanophlyctis), and fish fingerlings (Cirrhina mrigala) were followed at 0, 24, 48, 72, and 96 hr. The median tolerance limit values at 48 hr. were 0.013, 0.049, 0.060, 0.080, and 0.022 ppm for water fleas, tadpoles, slug worms, snails, mosquito larvae, and fingerling, respectively. Daphnia is the most susceptible species to detergents whereas mosquito larvae are fairly resistant. At concentrations of 0.01-0.04 ppm the rate of survival of tadpoles was 100% but on increasing the concentration from 0.04 to 0.05 ppm there was a sudden change in the rate of survival. In fish fingerlings, there was a sudden change in the rate of survival between 0.01 and 0.02 ppm. Behavioral changes were also observed in exposed animals. There were no significant changes in the physical characteristics of the water such as dissolved oxygen, pH, and surface tension. The observed toxic effects are likely to be due to xenobiotic stress rather than altered physical factors in the environment. (Moore-IVI)
W84-02778

HISTOLOGICAL ALTERATIONS IN LIVER AND INTESTINE OF TELEOST SAROTHERODON MOSSABICUS IN RESPONSE TO MERCURY TOXICITY,
Sri Venkateswara Univ., Tirupati (India). Dept. of Zoology.
K. A. Naidu, K. A. Naidu, and R. Ramamurthi.
Ecotoxicology and Environmental Safety, Vol. 7, No. 6, p 566-575, December, 1983. 18 Fig, 12 Ref.

Descriptors: *Toxicity, *Mercury, *Liver, *Intestine, *Sarotherodon, Fish, Heavy metals.

Effects of lethal (1.5 ppm) and sublethal (0.1 ppm) concentrations of HgCl2 on liver and intestine tissues of Sarotherodon mossambicus were studied by routine histological techniques. Engorged blood sinusoid, vacuolation, rupture, granular degeneration of hepatocytes, edema, focal necrosis, and proliferation of fibroblasts were the alterations observed in liver. Rupture of the tips of the villi, proliferation of villi, increase in goblet cell population, and focal necrosis of villi were the characteristic changes in intestine. (Author's abstract)
W84-02779

EFFECT OF RURAL HIGHWAY RUNOFF ON STREAM BENTHIC MACROINVERTEBRATES,
Wisconsin Univ.-Milwaukee. Dept. of Zoology.
M. E. Smith, and J. L. Kaster.
Environmental Pollution (Series A), Vol. 32, No. 3, p 157-170, 1983. 3 Fig, 4 Tab, 21 Ref.

Descriptors: *Highway effects, *Runoff, *Invertebrates, Stream pollution, Water pollution effects, Biomass, Abundance, Benthos, Wisconsin.

The impact of rural highway runoff on benthic macroinvertebrate abundance and composition was studied in a southeastern Wisconsin, USA, stream during 1980-81. The study suggests minimal effect on stream macroinvertebrates by rural highway runoff from roadways of 7000-8000 vehicles per day traffic volume. Differences in mean annual numbers and biomass between the control (4155/sq m, 10.5 g/sq m) and the station receiving slight highway runoff (2611/sq m, 5.2 g/sq m), presumably resulted from slower current and siltation at the latter. The station which received the greatest amount of runoff had higher mean annual numbers (13291/sq m) and biomass (62.2 g/sq m) than the control. Increased current and better substratum were probably responsible for masking potential highway effects at this station. Another station with intermediate amounts of highway runoff had similar annual mean numbers (4642/sq m) and biomass (10.6 g/sq m) to the control. Similar values for richness were found between stations. Pollution sensitive fauna were approximately half as abundant at the station with intermediate amounts of highway runoff, suggesting possible slight runoff influence. (Author's abstract)
W84-02784

COMPARATIVE STUDIES ON THE ABSORPTION OF CADMIUM AND COPPER IN LEMNA PAUCICOSTATA,
Shinshu Univ., Matsumoto (Japan). Dept. of Public Health.
Y. Nasu, M. Kugimoto, O. Tanaka, and A. Takimoto.
Environmental Pollution (Series A), Vol. 32, No. 3, p 201-209, 1983. 4 Fig, 15 Ref.

Descriptors: *Duckweed, *Cadmium, *Copper, Hydrogen ion concentration, Aquatic plants, Bioindicators, Ammonium, EDTA, Wastewater, Chelating agents.

Absorption of copper or cadmium in the duckweed Lemna paucicostata (strain 6746) was suppressed by the addition of EDTA to the medium. Only 30 micro M of EDTA was sufficient to prevent the absorption of copper at a concentration of 5-10 micro M whereas 400 micro M of EDTA was necessary to prevent the absorption of cadmium at the same concentration as copper. Ammonium ion added to the medium greatly suppressed copper absorption, but cadmium absorption was only slightly suppressed. The growth of Lemna was inhibited in proportion to the amount of copper or cadmium absorbed. The absorption of cadmium was higher, the higher the initial pH of the medium, but that of copper was not significantly affected by the initial pH between 3.6 and 5.1. Both cadmium and copper inhibited plant growth more strongly at pH 5.1 than at pH 4.1. The absorption mechanism and the mode of action of cadmium seem to differ from those of copper in Lemna paucicostata 6746. Ammonium ions and chelating agents commonly exist in rivers, wastewater and lakes, and the pH of these waters also varies with the kind of pollution they contain. Therefore, when Lemna is to be used as an indicator of water pollution or to purify wastewater, the condition of the water must be taken into account. (Moore-IVI)
W84-02785

RELATIONSHIPS OF ENVIRONMENTAL CONTAMINANTS TO REPRODUCTIVE SUCCESS IN RED-BREASTED MERGANSERS MERGUS SERRATOR FROM LAKE MICHIGAN,
Fish and Wildlife Service, Laurel, MD. Patuxent Wildlife Research Center.
G. H. Heinz, S. D. Haseltine, W. L. Reichel, and G. L. Hensler.
Environmental Pollution (Series A), Vol. 32, No. 3, p 211-232, 1983. 1 Fig, 2 Tab, 49 Ref.

Descriptors: *Ducks, *Reproduction, *Lake Michigan, *Water pollution effects, *Mergansers, Mortality, DDE, Pesticides, Behavior, Wisconsin.

For many years Lake Michigan has been known to be heavily contaminated with man-made chemicals. Red-breasted mergansers (Mergus serrator) nesting on islands in northwestern Lake Michigan were studied in 1977 and 1978 to determine whether environmental contaminants were having effects on reproduction. The studies were conducted on Spider, Pilot, Hog, Gravel and Plum Islands, off the tip of Door County, Wisconsin. Seventeen contaminants were measured in randomly chosen eggs from 206 nests under study. A variety of statistical approaches were used to study the effects of individual contaminants and combinations of contaminants on reproductive measurements such as nest desertion, failure of eggs to hatch, death of newly hatched ducklings, percentage hatching success, number of ducklings leaving the nest and eggshell thickness. Relationships between the levels of some contaminants in blood samples of 39 incubating females and reproductive success were examined. A small degree of eggshell thinning was attributed to DDE and a few other statistical tests were significant, but no contaminant or combination of contaminants measured seemed to have a pronounced effect on these aspects of reproduction. (Moore-IVI)
W84-02786

EFFECTS OF PCB ON THE ADRENERGIC RESPONSE IN PERFUSED GILLS AND ON LEVELS OF MUSCLE GLYCOGEN IN RAINBOW TROUT (SALMO GAIRDNERI RICH.),
Uppsala Univ. (Sweden). Inst. of Zoophysiology.
A. Kiessling, P. Part, and K. Lindahl-Kiessling.
Bulletin of Environmental Contamination and Toxicology, Vol. 31, No. 6, p 712-718, December, 1983. 4 Tab, 32 Ref.

Descriptors: *Polychlorinated biphenyls, *Trout, *Toxicity, Organic compounds, Industrial wastes.

Whether polychlorinated biphenyls (PCB) influence the adrenaline response in gills and/or glycogen storage in muscle was investigated using perfused gill preparations from PCB exposed rainbow trout. Experimental groups of 25 fish of both sexes were randomly selected and fed a total amount of 0.173 g PCB during a six day period. The response to adrenaline consisted of a major alpha-adrenergic vasoconstriction followed by a small betadilatation. There was no difference in adrenergic response in the gill vascular bed between PCB-exposed fish and the controls. In the presence of phentolamine, an alpha-adrenergic antagonist, adrenaline decreased gill vascular resistance significantly in both groups. No starvation effect on the levels of glycogen in the muscle were noted, although the fish were starved throughout the experimental period of 38 days. (Baker-IVI)
W84-02835

THE RISKS OF DRINKING WATER,
Harvard Univ., Cambridge, MA. Energy and Environmental Policy Center.

For primary bibliographic entry see Field 5F.
W84-02839

DETOXIFICATION OF ENVIRONMENTAL COPPER IN THE COMMON MUSSEL,
F. L. Harrison.
Energy and Technology Review, p 9-19, November, 1983. 6 Fig, 5 Tab, 12 Ref.

Descriptors: *Copper, *Mussels, *Water pollution effects, Mytilus edulis, Metals, Detoxification, Proteins, Chemical reactions, Metallothionein, Lysosomes.

Two mechanisms of metal detoxification were examined, the binding of copper to metallothionein-like proteins and the incorporation of copper into lysosome-like vesicles. Cells in the digestive gland and other soft tissues of mussels were examined following exposure to the range of copper actually associated with polluted ecosystems. The first step was to determine whether there were increased metals in the low-molecular weight fraction of metal binding proteins. The second was to evaluate the cytological effects of copper on lysosomes by measuring the unavailability for reaction of the lysosomal enzyme hexosaminidase. Changes were noted in the kinds and quantities of copper-binding proteins and in the latency of lysosomal enzymes occurring in the digestive gland cells of Mytilus edulis exposed to metals. Chronic exposure to copper resulted in copper concentrations in low molecular weight metallothionein-like proteins that were dependent on the exposure concentration and time. The copper concentration associated with high-molecular-weight proteins is directly related to the mortality of mussels. Copper exposure also results in a dose dependent reduction in the latency of lysosomal hexosaminidase activity. Exposure to sublethal concentrations of copper thus produces cytotoxic responses that appear to induce stress syndromes such as reduced body weight, low reproduction, and increased incidence of disease. (Baker-IVI)
W84-02931

A SITE-SPECIFIC FIELD AND LABORATORY EVALUATION OF FISH AND ASIATIC CLAM POPULATION RESPONSES TO COAL FIRED POWER PLANT DISCHARGES,
Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Biology.
J. Cairns, Jr., and D. S. Cherry.
Water Science and Technology, Vol. 15, p 31-58, 1983. 8 Fig, 7 Tab, 36 Ref.

Descriptors: *Field tests, *Laboratories tests, *Fish populations, Asiatic clams, Populations, *Coal fired power plants, *Wastes, Fish behavior, Ecological effects, Thermal stress, Heated water.

A combined effort of field receiving system monitoring and field located laboratory and formal laboratory bioassay testing was used to evaluate and compare responses of fish and the Asiatic clam (Corbicula fluminea) to power plant discharges. Discharges and effluents during an 8-yr period included thermal and chlorinated discharges and pH excursions from fly ash effluent released into a lotic receiving system of the New River drainage in Glen Lyn, Virginia, USA. Constituents within the fly ash effluent included the effects of the particulate ash fraction, heavy metals, and pH (acidic and alkaline) excursions. The field laboratory tested fish preference-avoidance behavior and lethal temperature responses to elevated temperatures in chlorinated, thermal plumes. The fish populations preferred and avoided heated waters, depending on their seasonal acclimation requirements. Fish populations avoided sublethal chlorinated discharges from laboratory intermittent chlorine bioassays after attraction into the laboratory and field thermal plumes. From October 1976-September 1978, Asiatic clams were more numerous in the vicinity of the thermal discharge of the plant than they were in unheated waters, and their population fell sharply during winter months when the water temperature dropped to approximately 2 degrees C. The temperature (35 degrees C) of the heated discharge water in late summer did not adversely affect the clam since in laboratory thermal tolerance studies mortality occurred at temperatures > or = to 36 degrees C. The clam proved to be highly resistant to the conventional biocidal practice of intermittent chlorination and to exposure to heavy metals in both static and artificial stream bioassays. Copper was more toxic than either zinc or a combination of zinc and copper. Potassium was not an effective biocidal (gaping) agent at low concentrations (<100 mg/l). Only minor incidents of Corbicula infestation were in the cooling system of the power plant, The ability of the clam to use heated discharge areas as overwintering sites has allowed them to expand their range into frozen northern aquatic systems of the USA. (Murphy-IVI)
W84-02935

IMPACT OF THERMAL POWER PLANTS ON AQUATIC ECOSYSTEMS: THE FRENCH EXPERIENCE,
Electricite de France, Chatou.
R. A. Gras.
Water Science and Technology, Vol. 15, No. 10, p 59-66, 1983. 2 Ref.

Descriptors: *Powerplants, *Thermal pollution, *Environmental effects, *Ecosystems, Fish, Public health, Aquatic life, France, Dissolved oxygen, Phytoplankton, Bacteria, Zooplankton, Plankton.

Field studies were conducted on the site of power plants currently in operation. These included Montereau powerplant, Bugey power plant, La Maxe power plant, Porcheville power plant, Saint-Laurent-des-Eaux power plant, Chinon power plant, Loire-sur-Phone power plant, and Les Ansereuilles power plant. Power plants by the sea which were studied included Dunkirk power plant, Martigues-Ponteau, and Gravelines. Power plants located on estuaries were also studied including Blayais, Cordemais and Ambes. Chemical wastes from the power plants are not released in sufficient quantity to significantly alter water quality. However waste heat may affect water quality either through direct impact causing a decrease in dissolved oxygen content or indirect impact caused by the long term changes in water temperature altering various components of the dissolved oxygen balance such as an increase in aeration at the water surface, a decrease in dissolved oxygen saturation level and other effects. Impacts on phytoplankton, zooplankton, and bacteria are reviewed. Sanitary effects are considered including those affecting public health, and fish parasites. (Baker-IVI)
W84-02936

THERMAL DISCHARGE AND FISH FAUNA IN SWEDEN,
National Swedish Environment Protection Board, Oregrund. Coastal Water Section.
E. Neuman.
Water Science and Technology, Vol. 15, p 67-87, 1983. 11 Fig, 7 Tab, 19 Ref.

Descriptors: *Heated water, *Fish, *Sweden, Fish behavior, Thermal stress, Thermal pollution, Thermal powerplants, Fish populations.

Investigations on the fish fauna at four thermal power plants in Sweden situated on Lake Malaren, the Baltic, the Sound and the Kattegatt, illustrate effects of thermal discharge in various salinities, from fresh water to above 20%. The most common species are classified as warm- or cold-water fishes on the basis of the catch/temperature relationship. The reactions towards the cooling-water mainly correspond to this grouping. There are exceptions due to special hydrographic conditions and to the supply of food. Shallow bottoms in freshwaters and at the Baltic coast are massively dominated by warm-water species of freshwater origin, while marine cold-water fishes hold a strong position in the higher salinities of the Sound and the coast of the Kattegatt. The effects of thermal discharge upon the species composition increases with salinity. (Murphy-IVI)
W84-02937

BIOLOGICAL MONITORING OF THERMAL EFFECTS OF COOLING WATER DISCHARGES FROM DANISH POWER PLANTS,
Vandkvalitetsinstitutet, Hoersholm (Denmark).
B. Moller, and K. I. Dahl-Madsen.
Water Science and Technology, Vol. 15, p 89-99, 1983. 5 Fig, 1 Tab, 7 Ref.

Descriptors: *Biological monitoring, *Ecological effects, *Cooling water, *Thermal powerplants, Heated water, Thermal pollution, Water quality management, Water quality standards, Bioindicators.

In the years from 1970-1982 52 site studies and monitoring studies have been carried out at major existing and planned power plants, in order to plan a system for water quality. An important part of the planning system is the description of size and distribution of excess temperature fields and the related biological conditions. In the biological monitoring, emphasis is placed on the benthic community as more vulnerable to the cooling water discharge. The studies have shown that the excess temperature field within the 1-2 degree isotherm can produce measurable changes in the benthic community. The temperature effect in the pelagic zone is marginal, however, some effects are seen at sites with a deep water intake of nutrient rich water. Entrainment of fish and zooplankton can be important in bays and estuaries. (Murphy-IVI)
W84-02938

THE ROLE OF FREE-LIVING AMOEBAE OCCURRING IN HEATED EFFLUENTS AS CAUSATIVE AGENTS OF HUMAN DISEASE,
Pittsburgh Univ., PA. Graduate School of Public Health.
M. A. Shapiro, M. H. Karol, G. Keleti, J. L. Sykora, and A. J. Martinez.
Water Science and Technology, Vol. 15, p 135-147, 1983. 6 Tab, 21 Ref.

Descriptors: *Amoebae, *Heated effluents, *Causative agents, *Human Disease, Pathogenic organisms, Pathogens, Naegleria fowleri, Primary amoebic meningoencephalitis, Acanthamoeba, Granulomatous amoebic encephalitis, Coal fired powerplants, Cooling towers, Powerplants, Thermal pollution.

Several pathogenic organisms may be frequently found in thermal effluents and cooling systems of coal fired power plants, including pathogenic Naegleria fowleri, the causative agent of an acute fatal human disease - primary amoebic meningoencephalitis (PAM). Two out of eight power plants investigated, harbored pathogenic N. fowleri in heated water or cooling towers. The occurrence of this organism was related to elevated temperatures. No significant correlation was found for other biological and chemical parameters. In addition, pathogenic Acanthamoeba which causes granulomatous amoebic encephalitis (GAE) was found in heated effluents from coal fired power plants. Nonpathogenic strains of N. fowleri as well as other free-living and 'harmless' amoebae were also very abundant in effluents from all investigated coal fired power plants and cooling towers. Several species of nonpathogenic amoebae were isolated from humidifiers and air conditioning systems. Serological testing of symptomatic human subjects has indicated that these organisms may be one of the causative agents of hypersensitivity pneumonitis. Antibodies were detected in all sensitized animals. All the sensitized animals displayed delayed onset respiratory responses. Not only pathogenic but also non-pathogenic free-living amoebae may be important causative agents of human disease. The occurrence of these organisms in cooling systems from coal fired power plants indicates that these facilities may be an important source of infection. (Murphy-IVI)
W84-02940

PREDICTING THE IMPACT OF POWER PLANTS DISCHARGES ON THE WATER QUALITY OF A RIVER WITH THE AID OF A MATHEMATICAL MODEL,
Electricite de France, Chatou. Direction des Etudes et Recherches.
Ph. Gosse.

Water Science and Technology, Vol. 15, No. 10, p 149-160, 1983. 8 Fig, 15 Ref.

Descriptors: *Powerplants, *Thermal pollution, *Water quality, *Mathematical models, Phytoplankton, Dissolved oxygen, Turbidity, Plankton, Biomass, Model studies, Rivers.

The development of large once-through cooling power plants has raised the issue of the dispersion of residual heat and of the thermal assimilative capacity of the receiving waters. Important experimental studies dealing with this impact have been undertaken since 1972 on three large rivers. The immediate effects of such plants is limited. In general, dissolved oxygen content and turbidity were not directly affected by the transit, but may be locally modified in accordance with the geometric properties of the intake or outlet channels. Border, Champ, Lair and Pourriot noticed no significant changes in the diversity and concentration of phytoplankton and zooplankton biomass before and after passage through the condensers of their powerplants. Long term alterations include possible acceleration in the kinetics of pollution decay, increases in the productivity of phytoplankton when temperatures are lower than 25 degrees C, modification of the dissolved oxygen content due to algal and bacterial activity, and possible increases in thermophile zooplankton populations. (Baker-IVI)
W84-02941

MODELLING THE CONSEQUENCE OF COOLING WATER DISCHARGE FROM THE 'VENDSYSSEL' POWER PLANT,
Vandkvalitetsinstitutet, Hoersholm (Denmark).
A. Malmgren-Hansen, and K. I. Dahl-Madsen.
Water Science and Technology, Vol. 15, p 177-196, 1983. 15 Fig, 11 Ref.

Descriptors: *Mathematical models, *Cooling water, *Thermal pollution, *Vendsyssel power plant, Ecological effects, Zooplankton-growth model, 1-dimensional hydraulic model, Eutrophication model, Water quality management.

Discharge of cooling water from power plants has various effects on the ecosystem in coastal areas. The effect on primary production due to the rise in temperature in the outlet area and the decimation of zooplankton organisms passing through the cooling system of the power plant can be calculated by means of mathematical models. Calculations of the consequences of a considerable increase in cooling water discharge from the 'Vendsyssel' power plant allows power plant planners to evaluate the possibility of violation of emission standards for the receiving area. The decimation of zooplankton is calculated by means of a combined 2-dimensional hydraulic and zooplankton-growth model. Calculations of the effects on primary production are carried out by use of a combined 1-dimensional hydraulic and eutrophication model. (Murphy-IVI)
W84-02943

MACROBENTHIC COMMUNITIES OF THE LOWER CHESAPEAKE BAY. III. SOUTHERN BRANCH OF THE ELIZABETH RIVER. BENTHIC STUDIES OF THE LOWER CHESAPEAKE BAY 6,
Old Dominion Univ., Norfolk, VA. Dept. of Biological Sciences.
S. D. Hawthorne, and D. M. Dauer.
Internationale Revue der gesamten Hydrobiologie, Vol. 68, No. 2, p 193-205, 1983. 4 Fig, 5 Tab, 23 Ref.

Descriptors: *Benthic environment, *Water pollution effects, *Harbors, *Chesapeake Bay, *Elizabeth River, Virginia, Estuaries, Sedimentation, Water quality, Invertebrates.

Macrobenthic invertebrates of an industrialized seaport ecosystem were studied seasonally from October, 1977 through July, 1978. Five stations were selected along the Southern Branch of the Elizabeth River, Virginia. Poly- to mesahaline conditions occurred in this estuary. Slightly acidic waters existed in the upper reaches of the study area due to drainage of tannic acids produced within the Great Dismal Swamp. Dissolved oxygen was relatively good throughout the study. From 70 grab samples collected at five stations, 11,667 individuals were obtained. They were identified to 60 taxa, of which 53 were identified to species. The number of species observed at a station ranged from 9 to 27. Spatial homogeneity was very high throughout the Southern Branch. Slightly acidic waters did not affect the community structure in the southern most reach. Temporal heterogeneity was also high with some variations due to habitat alteration and/or reproductive recruitment. A considerable increase in sand content was noted, corresponding with maintenance dredging of the river. No signficiant alterations in the benthic community occurred due to the sediment alteration. Benthic communities of estuaries, particularly in the lower polyhaline to mesohaline zones, are dominated by eurytopic species that are probably affected only by severe stresses induced by man's activities. (Baker-IVI)
W84-02950

5D. Waste Treatment Processes

LAND APPLICATION: A NEW APPROACH TO PLANT EFFLUENT TREATMENT,
Law Engineering Testing Co., Marietta, GA.
G. L. Taylor, L. A. Neal, and N. Dee.
Pulp and Paper, Vol. 57, No. 3, p 81-84, March, 1983. 3 Fig, 9 Ref.

Descriptors: *Land disposal, *Pulp wastes, Pulp and paper industry, Kraft mills, Industrial wastes, Wastewater treatment, Sludge disposal.

Design criteria have been developed to allow land treatment of many pulp and paper wastes including sludges and residues, primary and secondary treatment plant effluents, total mill raw waste, and leachate from onsite sludge landfills. Four major techniques of waste application include rapid infiltration, overland flow, spray irrigation, and soil incorporation. Pretreatment of waste prior to land application may be appropriate if it can be economically justified. One potential problem of land treatment systems is the possibility of not being able to operate them during inclement weather periods. A waste characterization study must be performed to determine the amount of land needed for adequate assimilation of waste in the soil. Land treatment does present an efficient process for color removal. (Baker-IVI)
W84-02511

REUSE OF WARM WATER ON PAPER MACHINE PAYS OFF AT MADISON,
Jordan (Edward C.) Co., Inc., Portland, ME.
H. L. Laskey, and E. R. Drechsel.
Pulp and Paper, Vol. 57, No. 9, p 46-47, September, 1983. 1 Fig, 1 Tab.

Descriptors: *Pulp and paper industry, *Water reuse, Industrial wastes, Cooling water, Cost benefit analysis, Whitewater, Pumping, Water conservation.

Major effluent problems arose with the replacement of an existing 100-tpd groundwater mill with a 250-tpd pressurized groundwood mill along with the addition of a 600-tpd paper machine to the existing 120-tpd paper machine capacity. A water conservation plan was developed to recover and re-use the warmed water from the cooling systems, to control lantern ring seal water use, to vacuum pump seal water provided from separators on vacuum lines, to filter backwash discharged directly to the river, to get maximum re-use of whitewater and use of high pressure freshwater showers, to devise a whitewater storage system and to employ water conservation steps at existing operations. Heat recovered from the warm water collection system is about 63% of the total heat recovered. Total recovered heat of 63,100,000 Btu/hour is worth $2,650,000 per year. Installed cost for the warm water collection piping was $61,000. All new mills should be designed with a complete clean cooling water reuse system. Existing mills would also realize a good return on investment by installing a clean arm water collection and reuse system. Additional benefits include decreased cost of pumping freshwater and decreased flow to the water treatment plant. (Baker-IVI)
W84-02512

CHARACTERISTICS OF ACTIVATED SLUDGE EFFLUENTS BEFORE AND AFTER BREAKPOINT CHLORINATION,
Clemson Univ., SC. Coll. of Engineering.
B. Trgovcich, E. J. Kirsch, and C. P. L. Grady, Jr.
Journal of the Water Pollution Control Federation, Vol. 55, No. 7, p 966-976, July, 1983. 8 Fig, 8 Tab, 29 Ref. NSF grant CME 77-12649.

Descriptors: *Sludge, *Chlorination, *Activated sludge process, *Effluents, Acidity, Dissolved oxygen, Wastewater treatment, Biodegradation, Organic matter, Hydrogen ion concentration, Dissolved oxygen.

Attempts were made to alter the quality of the organic matter leaving an activated sludge reactor through control of operational variables such as pH and dissolved oxygen (DO) concentration. Data collected from lab-scale activated sludge reactors has shown that while factors internal to the culture are the primary determinants of effluent character as evaluated by adsorptability, molecular size, and biodegradability, pH and DO concentrations did not have much effect as control variables on those factors. If the effluent is to be subjected to breakpoint chlorination, then the pH of the activated sludge reactor will influence the adsorptability of the organics remaining after chlorination. Operation of the activated sludge reactors at a DP concentration of 7 mg/L resulterl in effluent organics that were less resistant to biodegradation than those produced at a DO concentration of 1 mg/L, both before and after breakpoint chlorination. Chlorination adversely affected biodegradibility. (Baker-IVI)
W84-02563

STEP PRESSURE SEWERS ARE A VIABLE WASTEWATER COLLECTION ALTERNATIVE,
Winzler and Kelly, Eureka, CA.
D. J. Tollefson, and R. F. Kelly.
Journal of the Water Pollution Control Federation, Vol. 55, No. 7, p 1004-1014, July, 1983. 5 Fig, 5 Tab, 5 Ref.

Descriptors: *Wastewater collection, *Sewer systems, *STEP pressure sewers, Septic tanks, Design criteria, Wastewater treatment, Construction costs, Groundwater pollution, Water pollution control, Bacteria, Manila, California.

The available information on low-pressure septic tank effluent pumping (STEP) sewer system was reviewed. STEP pressure sewers proved to be a viable alternative to conventional methods of wastewater collection under some conditions such as high ground water, undulating terrain, unstable soil or rock conditions, and rural community nature. Hydraulic design of STEP systems deserves careful attention so as to minimize construction cost and on-going costs. STEP collection system operation and maintenance costs total about $5.50 per customer per month of which $1.35 per month is electrical power related cost. Surface and groundwater samples were collected and analyzed for fecal coliform bacteria from system start-up through the monitoring program to assess the effect of the system on water quality. A significant improvement in groundwater quality resulted from construction of the STEP collection system in Manila, California. (Baker-IVI)
W84-02564

COST OF CLEAN WATER--IMPACT ON SMALL COMMUNITIES,
McNamee, Porter and Seeley, Ann Arbor, MI.
R. J. Smit, and W. A. Chapin.
Journal of the Water Pollution Control Federation, Vol. 55, No. 5, p 444-447, May, 1983. 3 Fig, 3 Tab, 5 Ref.

Descriptors: *Wastewater treatment facilities, *Construction costs, Grants, Loans, Small communities, Water pollution control, Income, Economic aspects.

The impact of grant reductions and changes in the classification of eligible project costs resulting from the Municipal Wastewater Treatment Grant Amendments of 1981 will significantly affect small communities. Owing to the state priority systems and other factors, small communities have received a disproportionately small share of EPA grants in terms of numbers and dollars. A substantial backlog of necessary water pollution control projects in small communities and scheduled reductions in the construction grants program make it likely that many small communities will have to construct their improvements with reduced grant support or none at all. This prospect may place the cost of wastewater treatment outside the reach of many small communities. Because annual household costs for wastewater treatment in smaller communities are higher than in large ones, and the median household income is generally smaller, the percentage of families that would be burdened by excessive costs for wastewater treatment would be larger. The use of less costly methods of wastewater treatment, such as lagoons or trickling filters, which may be permitted where they do not cause water quality degradation, does reduce user costs. Unfortunately, this substitution will not entirely offset reductions in grant support. Low interest loans, however, such as the 5%, 40-year loans available through the Farmers Home Administration, in combination with a 55% grant, can yield user charges comparable to those under the current 75% grant program. (Moore-IVI)
W84-02565

EFFECTS OF OZONE ON THE BIODEGRADABILITY OF BIOREFRACTORY POLLUTANTS,
D. R. Medley, and E. L. Stover.
Journal of the Water Pollution Control Federation, Vol. 55, No. 5, p 489-494, May, 1983. 8 Fig, 1 Tab, 21 Ref.

Descriptors: *Ozonation, *Wastewater treatment, Biodegradation, 1,2-Dichloropropane, 2,4-Dinitrophenol, Acrylonitrile, Industrial wastes, Oxidation, Phenols.

The effect of ozone on biodegradability of acrylonitrile, 1,2-dichloropropane, and 2,4-dinitrophenol was investigated. Acrylonitrile was not readily oxidized by ozone, even at considerable doses. 1,2-Dichloropropane was oxidized readily at very small ozone doses. TOC and COD followed an almost linear decreasing relationship with increasing absorbed ozone concentrations. Unozonated, 1,2-dichloropropane was totally resistant to biodegradation showing zero ultimate BOD with the acclimated seeds. 2,4-Dinitrophenol was not oxidized to a great extent by low ozone doses. Ozonation was effective in increasing the biodegradation of 2,4-dinitrophenol, with the increase being proportional to adsorbed ozone dose. Biological oxidation is possible for 2,4-dinitrophenol if concentrations are below inhibitory levels. Ozonation of 2,4-dinitrophenol prior to biological oxidation increases biodegradation and reduces inhibitory levels. Ozone is not a cure-all for difficult to biodegrade pollutants. Studies must be conducted on each compound to determine if it is effective or economically feasible to increase biodegradation or to oxidize the compound completely. (Baker-IVI)
W84-02566

CAPACITY OF NATURAL WETLANDS TO REMOVE NUTRIENTS FROM WASTEWATER,
North Central Forest Experiment Station, Grand Rapids, MN. Forestry Sciences Lab.
D. S. Nichols.
Journal of the Water Pollution Control Federation, Vol. 55, No, 5, p 495-505, May, 1983. 4 Fig, 2 Tab, 125 Ref.

Descriptors: *Wastewater treatment, *Land disposal, *Nutrients, Phosphorus Nitrogen, Wetlands, Aluminum, Iron, Calcium, Minerals, Clays, Denitrification, Adsorption.

Application of treated wastewater to wetlands is gaining attention as a simple method and energy-efficient way of nutrient removal. Wetlands retain wastewater P by adsorption and precipitation reactions with Al, Fe, and Ca in the soil. Adsorption/precipitation is not a limitless sink, and with continued application, the capacity of wetland soils to retain P declines as the soils become saturated. Adsorption is at least partially reversible. Some P that is adsorbed from the water at high concentrations can be released to the water when P levels are lower. Wastewater N is removed by denitrification in the wetland soil. Denitrification is dependent on a supply of available organic carbon. In typical wetlands with large amounts of organic matter in the soil, N removal does not seem to decline with time, in contrast to P removal. Wetland vegetation can adsorb large quantities of N and P during the growing season, but much of it is released to the water when the plants die. The removal of wastewater N and P by wetlands is most efficient at low N and P loading rates. Removal efficiency of both N and P falls off rapidly as loadings are increased. On the average, perhaps 1 ha of wetland is required to remove 50% of the N and P from the wastewater produced by 60 people. Much larger wetland areas are needed for higher removal efficiency. Application to natural wetlands can be an efficient method of wastewater nutrient removal if wetland is abundant and populations are low. (Baker-IVI)
W84-02567

FACTORS AFFECTING FINE BUBBLE DIFFUSED AERATION,
Rexnord, Inc., Milwaukee, WI.
G. L. Huibregtse, T. C. Rooney, and R. C. Rasmussen.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1057-1064, August, 1983. 10 Fig, 5 Ref.

Descriptors: *Wastewater treatment, *Aeration, Bubbles, Activated sludge processes, Efficiency, Evaluation, Systems analysis, Oxygen transfer.

To better understand factors that affect the performance of a fine bubble system, a series of clean water, unsteady-state, oxygen transfer tests was conducted. The major objective of the study was to provide comparative data under similar conditions for different shapes and configurations of fine bubble diffused aeration equipment. The program evaluated both a disc- and dome-type diffuser installed in a total-floor-coverage type configuration. Using the disc diffuser, testing was also conducted to determine the effect of diffuser size, as well as the installation density. Fine bubble tubes were also tested under the same conditions. For a fine-bubble-grid type system, percent oxygen transfer will be dependent on the liquid depth, diffuser shape and size, air flow rate per diffuser, and the number of diffusers installed. When system performance was measured in terms of overall aeration efficiency, the same test variables, with the exception of liquid depth, were found to have similar effects. Liquid depth had no significant effect on aeration efficiency. For a fine bubble tube system, performance will be dependent on the liquid depth, the air flow rate per tube, and the number of headers. Best test results were obtained with a dual header system at a low air flow rate per tube and at greater depths. (Baker-IVI)
W84-02573

EFFECTS OF DISSOLVED OXYGEN AND MIXING ON ALGAL AUTOFLOTATION,
Florida Univ., Gainesville. Dept. of Environmental Engineering Sciences.
J. Arbelaez, B. Koopman, and E. P. Lincoln.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1075-1079, August, 1983. 8 Fig, 1 Tab, 14 Ref.

Descriptors: *Wastewater treatment, *Algae, *Autoflotation, Dissolved oxygen, Mixing, Cultivation, Animal wastes, Flotation, High-rate ponds.

Pig wastewater influent to a high-rate pond was pre-treated by settling only. The autoflotation test apparatus consisted of an inlet and pump, plug flow reactor, and flotation cylinder. Data from all flotation trials were grouped according to the following contact times: 0.02 to 0.1, 0.1 to 1.0, 1.0 to 20, 20 to 100, 100 to 200, and greater than 200 seconds. Rise rates are highly sensitive to contact time at small values of contact time (0.02 to 20 seconds), but relatively insensitive at higher values of contact time. Velocity gradient and contact time were identified as important parameters in algal autoflotation. The theory that their product provides a single parameter that should correlate well with all results of flotation trials was tested. Velocity was shown to be inversely and consistently related to the product of the two parameters. However, the variability at the lowest product ranges indicates either instability of flotation in this regime or unequal importance of velocity and contact time in determining flotation performance. (Baker-IVI)
W84-02575

METRO ATLANTA WATER POLLUTION CONTROL - A DECADE OF PROGRESS,
R. Troxler, D. Reinhart, and A. Hallum.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1121-1127, September, 1983. 7 Fig, 2 Tab.

Descriptors: *Wastewater treatment facilities, *Water pollution control, *Atlanta, Georgia, Chattahoochee River, Peachtree Creek, DeKalb County, Cobb County, Lake Lanier, South River, Jackson Lake, Yellow River, Flint River, Etowah River, River basins.

Dramatic progress has been made during the past 10 years toward improved water quality using a variety of technical solutions for the city of Atlanta, Georgia. In the Chattahoochee River Basin, even though four wastewater treatment plants discharge into the reach above Peachtree Creek, the major water quality problems are from urban runoff and construction-generated sediment. The quality of the water decreases severely below Peachtree Creek, with the river receiving the discharges from five major wastewater treatment plants. Improvement in this area has been largely due to the addition of secondary treatment capability at the R. M. Clayton Plant in Atlanta, one of the largest treatment facilities in the southeast. The South River Basin has received severely polluted discharges from Atlanta and DeKalb County and large blooms of algae each year during the summer and fall in Jackson Lake have only added to the problem. Steps for better control in this area include construction of an above ground storage facility at the site of a third major combined sewer overflow point in the South River Basin. The screened and degritted effluent from this facility will be discharged into a separate sanitary sewer that is tributary to the South River Plant. Specific efforts have also been made in the Yellow River Basin, the Flint River Basin and the Etowah River Basin. (Baker-IVI)
W84-02580

A QUALITY ASSURANCE PROGRAM AT A MUNICIPAL WASTEWATER TREATMENT PLANT LABORATORY,
Milwaukee Metropolitan Sewerage District, WI. Treatment Services Div.
G. A. Aldenhoff, and L. A. Ernest.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1132-1137, August, 1983. 1 Fig, 2 Tab, 4 Ref.

Descriptors: *Water quality control, *Wastewater treatment facilities, Municipal wastewater, Quality control, Milwaukee, Wisconsin, Maintenance, Management, Planning.

The Milwaukee Metropolitan Sewerage District (MMSD) laboratories monitor wastewater treatment plant processes, provide research support, analyze industrial waste contributions, evaluate water quality variables in receiving streams and Lake Michigan, and measure the constituents of solids generated by the treatment plants' processes. The MSSD concentrates its quality assurance program on the individual analyst and his daily con-

trols. Each analyst is responsible for quality control in his area. He determines and controls the quality of the physical, chemical, or biological measurement, as well as data handling, reporting, and visual representation of that data. To establish precision, a regular program of duplicate and replicate analyses is carried out. Although precision testing verifies the repeatability of the method, it does not guarantee accuracy. This is accomplished by analyses of check standards and spikes and shows the degree of difference between the observed and the known or true values. Control charts in use at the district are of three types: one for duplicate analysis, a second for recoveries of standards, and a third for recoveries in spiked samples. Control charts are the last step taken by the analyst at the end of each day's run. They are specifically designed to make him aware of what the limits are, whether or not the system is in control, and whether or not a pattern of impending trouble is occurring. (Baker-IVI)
W84-02581

COMPREHENSIVE PROGRAM FOR SURVEILLANCE OF PACKAGE PLANTS AND STABILIZATION PONDS,
Mid-Ohio Valley Health Dept., Parkersburg, WV.
R. G. Weigand.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1138-1143, September, 1983. 2 Fig, 2 Tab, 3 Ref.

Descriptors: *Quality control, *Wastewater treatment facilities, Stabilization ponds, Monitoring, Water pollution control, Planning, Management, Maintenance, West Virginia, Wood County.

Since its inception in 1975 the small wastewater treatment system surveillance program of the Wood County Health Department (West Virginia) currently in place has expanded to involve not only operation and maintenance inspections, but plan review, site review, and construction inspections. The main thrust of the program lies with routine maintenance inspections performed semiannually at each plant and stabilization pond. Detailed inspection forms that stress routine maintenance activities have been created to aid the inspector and operator. Strong emphasis on proper planning and construction resulted in fewer serious maintenance problems, and plants that are more operable. The heavy emphasis placed on operator training is evidenced by the significant increase in certified operators since the program began. Where maintenance deficiencies are noted, the technical assistance approach has been much more successful than has the enforcement approach for obtaining compliance. Although most effluent analyses are limited to portable kits for parameters such as pH, alkalinity, and chlorine residual, a dissolved oxygen meter has been useful in monitoring oxygen levels in mixed liquor samples. Further study is needed to examine the efficiency and overall success of different management structures for these small wastewater systems. Additional work also is needed to determine the feasibility of various filter media being used for surface sand filters. (Baker-IVI)
W84-02582

INEXPENSIVE HEAVY METAL REMOVAL BY FOAM FLOTATION,
Vanderbilt Univ., Nashville, TN. Dept. of Civil and Environmental Engineering.
G. McIntyre, J. J. Rodriguez, E. L. Thackston, and D. J. Wilson.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1144-1149, September, 1983. 3 Fig, 6 Tab, 8 Ref.

Descriptors: *Heavy metals, *Foam separation, *Flotation, Wastewater treatment, Industrial wastes, Chromium, Copper, Zinc.

The removal of copper and zinc, mixtures of copper and zinc, and chromium by adsorbing colloid foam flotation was investigated. The method proved feasible for treatment of heavy metals-bearing wastewaters. Effluent concentrations below the 1984 Best Available Technology (BAT) limits can be consistently obtained for all the heavy metals studied, even when dealing with wastes containing mixtures of them. The cost of the process is probably competitive with lime precipitation, and may be considerably less if lime precipitation requires filtration of final effluent, or if the total costs of sludge handling are considered, or if additional land is necessary to accommodate a clarifier. Chemical costs associated with foam flotation are considerably higher than for lime precipitation, but the chemical addition allows much higher areal loading rates, resulting in much lower capital costs for foam flotation. (Baker-IVI)
W84-02583

NITROGEN CONTROL IN DOMESTIC WASTEWATER RAPID INFILTRATION SYSTEMS,
Robert S. Kerr Environmental Research Lab., Ada, OK. Wastewater Management Branch.
L. E. Leach, and C. G. Enfield.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1150-1157, September, 1983. 9 Fig, 3 Tab, 13 Ref.

Descriptors: *Domestic wastewater, *Land disposal, *Infiltration, *Nitrogen removal, Wastewater treatment, Nitrates, Sprinklers, Rapid infiltration, Algae, Hydraulic loading.

The effect of flooding and drying scheduling on hydraulic loading and nitrogen removal was investigated. Total nitrogen and nitrate-nitrogen in secondary effluent is effectively reduced and maintained at acceptable levels through rapid infiltration land treatment systems. The most efficient of the four operating schedules evaluated occurred with an operation of 1-day flooding followed by 1-day drying. Long term flooding and the 3-day flooding followed by 4-day drying cycles both performed about equally well hydraulically. Although these cycles were the most efficient for total volume of wastewater treated per unit of time, they were not as efficient for nitrogen control as 1-day cycles; and they presented a problem during the drying cycle with the development of high nitrates in the soil water. High concentrations of nitrogen were flushed through the soil at the beginning of each new flooding cycle. The magnitude of nitrate concentration was greatly reduced in the 1-day cycle operation, compared to the two longer flooding schedules. Bed surface management was also much more efficient. Application of wastewater with sprinklers in 15 minute cycles interrupted by 75 minutes of drying eliminated flushing slugs of high concentrations of nitrogen through the soil system. However, nitrate concentrations were consistently above the 10 mg/l Public Health Service Drinking Water Standard. An alternative conclusion could be made that the most effective scheduling for hydraulic loading was the least effective for nitrogen removal. Removal efficiencies as high as 80% could be achieved if loading were reduced to 15 cm/d, but removal would drop to about 20% if the loading were increased to 50 cm/d. Algal blooms did not develop with operation of the sprinkler system and bed maintenance was not needed, but all flooding operations were plagued by nuisance algal blooms. (Baker-IVI)
W84-02584

CONTROL OF OZONE DISINFECTION BY EXHAUST GAS MONITORING,
Municipal Environmental Research Lab., Cincinnati, OH. Wastewater Research Div.
A. D. Venosa, and M. C. Meckes.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1163-1167, September, 1983. 5 Fig, 2 Tab, 11 Ref.

Descriptors: *Ozonation, *Disinfection, Ozone, Wastewater treatment, Secondary wastewater treatment, Activated sludge processes, Contact stabilization, Rotating biological contactors.

Secondary effluent was obtained from six different sources, three of which are conventional activated sludge treatment plants, two are contact stabilization plants, and one uses rotating biological contactors to treat municipal wastewater. Five receive raw wastewater of municipal origin while the sixth receives wastewater with a high concentration of industrial wastes. Disinfection with ozone can controlled by monitoring the exhaust gas ozone concentration exiting the contactor. This method was more reliable than measuring dissolved ozone because of the inherent difficulties and inadequacies of state-of-the-art dissolved residual techniques. The advantages of measuring exhaust gas ozone include: true ozone is being measured free of interferences; ozone demand of the effluent and transfer efficiency of the contactor are automatically accounted for in one measurement; the method is easily automated; instruments are already available on the market for measuring ozone in the gas phase with accuracy, precision, and low level sensitivity; and ozone is more stable in the gaseous phase than in the liquid phase, and consequently the operator does not have to concern himself with dissipation of the zone from the time it leaves the contactor to the time it arrives at the analyzer. (Baker-IVI)
W84-02585

BIODEGRADATION AND ADSORPTION WITHIN ACTIVATED CARBON ADSORBERS,
Zenon Environmental, Inc., Burlington (Ontario).
R. G. Peel, and A. Benedek.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1168-1173, September, 1983. 10 Fig, 29 Ref.

Descriptors: *Wastewater treatment, *Activated carbon, *Adsorbents, *Biodegradation, *Adsorption, Activated sludge process, Filtration,.

In a biologically active carbon filter the two processes of adsorption and biological degradation occur simultaneously and the extent of each is difficult to determine because the processes are not easily isolated without significantly influencing process conditions. When biodegradable organics are present in the influent to an activated carbon column, biochemical oxidation can be presumed to occur when sufficient oxygen is present. If, however, the organic components of the feedstream are relatively non-biodegradable, very little, if any, biochemical oxidation will occur. Activated carbon does not have an inherent bio-enhancement capability, and organics that can be regarded as biorefractory to conventional treatments will also be biorefractory within a biologically active carbon column. The close agreement obtained between the experimental breakthrough curves and the breakthrough curves predicted by the dual-rate kinetic model show that relatively simple modeling approaches using an overall parameter, such as total organic carbon, can be very useful in predicting the behaviour of adsorbers in which the removal of organics is predominantly caused by adsorption. (Baker-IVI)
W84-02586

METALS REMOVALS AND PARTITIONING IN CONVENTIONAL WASTEWATER TREATMENT PLANTS,
Municipal Environmental Research Lab., Cincinnati, OH.
A. C. Petrasek, Jr., and I. J. Kugelman.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1183-1190, September, 1983. 1 Fig, 8 Tab, 25 Ref.

Descriptors: *Wastewater treatment, *Metals, *Activated sludge process, Calcium, Silver, Arsenic, Cadmium, Chromium, Copper, Iron, Mercury, Magnesium, Manganese, Nickel, Lead, Zinc, Industrial wastes, Cincinnati, Ohio.

The removal and partitioning of metals normally present in wastewater entering the Mill Creek Wastewater Treatment Plant in Cincinnati were determined in a pilot-scale activated sludge system. Twenty-four hour composite samples were collected for all process flows and sludges throughout the duration of the project. The metals concentrations observed in the primary sludge were generally higher than in the return activated sludge, when considered in units of mg/L. However, on a mg/kg basis the waste activated sludge had higher concentrations. The primary sludge contained 10 to 15% of the metals entering the plants. Waste

activated sludge contained about 30% of the total metals burden. The average removal of the 13 metals studied was 42%, based on the mass balance calculations. Silver, mercury and arsenic were present at very low concentrations in the raw wastewater and proper assessment of removability was not possible. Arsenic removal was 19%. Calcium and magnesium are quite refractory to the biological processes and there was essentially no removal of these metals. Manganese removal for the total treatment sequence was on the average only 39%, with the primary clarifier removing 15% and the activated sludge process removing 27%. Other metals studied included cadmium, chromium, copper, iron, nickel, lead, and zinc. (Baker-IVI)
W84-02588

A PRACTICAL METHOD TO ESTIMATE THE ACETOCLASTIC METHANOGENIC BIOMASS IN ANAEROBIC SLUDGES,
Ghent Rijksuniversiteit (Belgium). Faculteit Landbouwwetenschappen.
D. Valcke, and W. Verstraete.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1191-1195, September, 1983. 2 Fig, 3 Tab, 18 Ref.

Descriptors: *Anaerobic digestion, *Methane, *Acetate, *Sludge, Wastewater treatment, Activated sludge processes, Sodium acetate, Methanogenesis, Bacteria, Biomass.

The method consists of adding increasing amounts of acetate to a series of sludge samples, thus determining the maximum rate of methane production per liter of mixed liquor. The method is based on the finding that during a maximum of 24 hrs of incubation, biomass growth is minimal and acetate conversion rates obey zero-order kinetics and are not affected by substrate concentrations between certain limits. To convert the determined maximum rate to acetoclastic biomass it is assumed that maximum specific activity is attained. The sludge of an upflow reactor treating wastewater from a flax retting factory was used to verify the test procedure. Different concentrations of sodium acetate were added and monitored for conversion over a 30 hr period. Linear production rates were observed varying from 275 to 425 mL methane/L of mixed liquor/day. Higher sludge concentrations gave higher methane production rates. Acetate is rate-limiting below a sludge load of 0.40 g HAc/g volatile suspended solids, with this particular sludge. Therefore it was necessary to dilute the sludge to a concentration of 5 g VSS/l or less to assure substrate-non-limiting conditions. (Baker-IVI)
W84-02589

EXERTION OF 5-DAY NITROGENOUS OXYGEN DEMAND IN NITRIFYING WASTEWATERS,
Metropolitan Sanitary District of Greater Chicago, IL.
B. Washington, C. Lue-Hing, D. R. Zenz, K. C. Rao, and A. W. Obayashi.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1196-1200, September, 1983. 1 Fig, 4 Tab, 12 Ref.

Descriptors: *Nitrification, *Oxygen demand, Wastewater treatment facilities, Wastewater treatment, Domestic wastes, Chicago, Illinois, Municipal wastes, Secondary wastewater treatment.

The amount of nitrogenous oxygen demand (NOD) associated with different types of wastewater samples obtained from several sources was determined using the standard BOD5 test. The sources included plant samples taken from the three major sewage treatment works in the Chicago area, in addition to samples obtained from various ongoing full-scale nitrification projects. The West-Southwest, North Side and Calumet sewage treatment works are conventional activated sludge, secondary wastewater treatment facilities that discharge unfiltered, chlorinated final effluents. A substantial NOD5 was exerted in both completely nitrified and partially nitrified wastewaters consisting of raw wastewater, primary effluents and final effluents, including those final effluents that were chlorinated. The ammonia-nitrogen contained in the BOD dilution water contributed significantly to the NOD when the residual ammonia-nitrogen in the wastewater samples was low (less than 1 mg/L). Suspended solids removal by filtration considerably reduced the amount of carbonaceous BOD5 measured in the filtered effluents. Removal of nitrifying bacteria by filtration considerably reduced the amount of NOD5 exerted. To consistently operate with an effluent BOD5 of less than 10 mg/liter, sewage treatment works will be required to operate in a mode that will produce effluents with ammonia-nitrogen concentrations of less than 1.0 mg/L, and carbonaceous BOD5 contents of less than 5.0 mg/L. However, the inclusion of filtration at facility would further enhance the ability of the facility to meet the BOD5 standard of 10 mg/L. (Baker-IVI)
W84-02590

A MANAGEMENT APPROACH TO ENERGY COST CONTROL IN WASTEWATER UTILITIES,
Peat, Marwick, Mitchell and Co., Washington, DC.
For primary bibliographic entry see Field 6B.
W84-02592

LEAST COST PROCESS DESIGN FOR GRANULAR ACTIVATED CARBON ADSORBERS,
Zenon Environmental, Inc., Burlington (Ontario).
For primary bibliographic entry see Field 6B.
W84-02593

A NEW DESIGN PROCEDURE FOR WASTE STABILIZATION PONDS,
Technische Univ., Dresden (German D.R.).
D. Uhlmann, F. Recknagel, G. Sandring, S. Schwarz, and G. Eckelmann.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1252-1255, October, 1983. 4 Fig, 1 Tab, 11 Ref.

Descriptors: *Design criteria, *Stabilization ponds, Biochemical oxygen demand, Lagoons, Wastewater treatment, Temperature.

A procedure has been developed that can be used either to calculate the first-order BOD removal coefficient for a given combination of volumetric BOD loading, mean water residence time, and mean temperature for periods greater than 1 month or to find out the optimum combination of mean temperature and number of ponds arranged in series to meet a pretended effluent standard at a given inflowing substrate and water residence time. The equation for the removal coefficient was derived from lab experiments with semicontinuous-flow models of stabilization ponds and covers a broad range of residence times from 4 to 100 days, volumetric BOD loading from 1 to 25 grams/cu m/day, and temperature from 2 to 40 degrees C. The validation of the design procedure was based on the results scaled-up from the laboratory models as compared to the BOD removal measured in large-scale ponds. There was a reasonable degree of correspondence between calculated and actually measured BOD removal. This also applied to the calculation of the performance of stabilization ponds in tropical climates. The method is confined to ponds in series: the removal coefficient has to be calculated for the total pond volume and can then be used to obtain the outflow BOD for the individual ponds within the series. A sensitivity analysis revealed that the change in BOD removal responded to changes in the mean residence time and mean temperature less dramatically than to changes in the inflowing substrate. (Baker-IVI)
W84-02594

ALGAE REMOVAL BY THE OVERLAND FLOW PROCESS,
J. L. Witherow, and B. E. Bledsoe.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1256-1262, October, 1983. 2 Fig, 3 Tab, 12 Ref.

Descriptors: *Overland flow, *Algal control, Weed control, Algae, Total suspended solids, Lagoons, Phytoplankton, Secondary wastewater treatment.

Algae removal by the overland flow process was evaluated and the suitability of lagoons for preapplication treatment was determined. The use of facultative lagoons for preapplication treatment for the overland flow process has economic advantages where storage is needed or where more than screens or comminutors are required. The overland flow process has a surface discharge and must meet NPDES secondary treatment limitations to be viable. The process preceeded by a facultative lagoon did not meet the secondary treatment limits for total suspended solids during algal bloom periods when the number of algae are two to three orders of magnitude greater than usual. Both the number and species of plankton in the applied wastewater controlled the ability of the overland flow process to meet these limits. (Baker-IVI)
W84-02595

THE ROLE OF SUSPENDED PARTICLES IN ULTRAVIOLET DISINFECTION,
North Carolina Univ. at Chapel Hill. Dept. of Environmental Sciences and Engineering.
R. G. Qualls, M. P. Flynn, and J. D. Johnson.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1280-1285, October, 1983. 4 Fig, 4 Tab, 23 Ref. EPA grant R 804770010.

Descriptors: *Disinfection, *Ultraviolet radiation, *Suspended solids, Particulates, Wastewater treatment, Bacteria, Coliforms, Viruses, Filtration, Spectrophotometry.

The effects of absorbed and scattered UV light, and their role in intensity measurement; the effects of exclusion of various particle sizes on the dose-survival curves of coliforms in wastewater; and the effects of mixed-media filtration in a pilot-scale ultraviolet disinfection study were investigated. Suspended particles in wastewater effluents play two roles in UV disinfection: they absorb and scatter the UV light and harbor bacteria that are partially protected from the UV light. Normal spectrophotometric measurements significantly overestimate UV absorbance in wastewater because of scattering. The opalescent plate method of making spectrophotometric UV absorbance measurements gave a close estimate of true absorbance and was not significantly affected by scattering. Disinfection was significantly better in a sand-anthracite filtered effluent than in the unfiltered secondary effluent. Coliforms associated with particles were partially protected from UV disinfection. These protected coliforms were the major factor limiting improved disinfection at -3 or -4 log survival units. (Baker-IVI)
W84-02597

PREDICTING REMOVAL OF TRACE ORGANIC COMPOUNDS BY BIOFILMS,
Illinois Univ. at Urbana-Champaign. Dept. of Civil Engineering.
E. Namkung, R. G. Stratton, and B. E. Rittmann.
Journal of the Water Pollution Control Federation, Vol. 55, No. 11, p 1366-1372, November, 1983. 6 Fig, 2 Tab, 16 Ref.

Descriptors: *Biofilms, *Organic compounds, *Wastewater treatment, Model studies, Kinetics, Substrates,.

The concept of secondary utilization by biofilms, which allows trace concentrations of organic contaminants to be removed biologically to still lower levels, is evaluated experimentally and theoretically. Five simple organic compounds (acetate, alanine, galactose, thymine, and phenol) were selected as substrates for this biofilm study. The different secondary substrates had different removal profiles when acetate was the primary substrate. Thymine was not readily used as a secondary substrate, and alanine was the most completely removed. The interaction between primary substrate, which maintains the biofilm, and the secondary substrate determines the feasibility of secondary utilization. Each secondary substrate was tested at different feed concentrations. In general, percent substrate

removal increased as the feed concentration was lowered. The effects of concentration changes were most significant for thymine, the least quickly degraded secondary substrate. Modeling secondary utilization by biofilms involves predicting the use of the secondary substrates by the steady-state biofilm; the biomass has already been established by primary substrate utilization. The non-steady-state biofilm model can successfully explain and predict the performance of laboratory scale biofilm reactors for short term secondary utilization if the biofilm thicknesses for the steady state condition are based on primary substrate use and if independently determined kinetic parameters are available for the secondary substrates. (Baker-IVI)
W84-02602

COMPOSITE SAMPLES OVERESTIMATE WASTE LOADS,
Illinois State Environmental Protection Agency, Springfield. Div. of Water Pollution Control.
D. J. Schaeffer, H. W. Kerster, D. R. Bauer, K. Rees, and S. McCormick.
Journal of the Water Pollution Control Federation, Vol. 55, No. 11, p 1387-1392, November, 1983. 4 Tab, 13 Ref.

Descriptors: *Sampling, *Composite samples, Waste loads, Estimating, Wastewater treatment facilities, Monitoring.

Composite samples are generally believed to be more representative than grab samples of process stream average performance. If flows and concentrations are uncorrelated and lack autocorrelation, the same applies to the mean concentration of grabs and composites. However, the true variance of flow proportional (FP) composites is larger than that of grab samples or time proportional to flow (TP) composites. Loads computed from FP composites are biased because of the volume weighting of subsamples during FP composting. When flows and concentrations are correlated, then volume proportional to flow (VP) and TP composites produce biased estimates of the mean and variance of concentrations, as well as of loads. The bias arising from the correlation between flow and concentration substantially exceeds that arising from proportioning. As a result, regulatory monitoring data obtained from composite samples must be viewed with suspicion. (Baker-IVI)
W84-02603

DEGRADATION OF CHLOROPHENOLS BY A DEFINED MIXED MICROBIAL COMMUNITY,
Gesamthochschule Wuppertal (Germany, F.R.). Lehrstuhl fuer Chemische Mikrogiologie.
E. Schmidt, M. Hellwig, and H. J. Knackmuss.
Applied and Environmental Microbiology, Vol. 46, No. 5, p 1038-1044, November, 1983. 6 Fig, 13 Ref.

Descriptors: *Chlorophenols, *Microbial degradation, *Biological wastewater treatment, Chlorocatechols, Pseudomonas, Alcaligenes.

Synthetic sewage containing phenol, acetone, and alkanols plus 4-chlorophenol or mixture of isomeric chlorophenols is completely degraded by a defined mixed culture with Pseudomonas sp. strain B13 as a chlorocatechol-dissimilating member of the community. Total degradation of the organic carbon was indicated by release of stoichiometric amounts of chloride and low content of dissolved organic carbon in the cell-free effluents. During adaptation to high loads of chlorophenols the initial meta-cleavage activity was completely replaced by ortho-cleavage activity of type I and II. In the fully acclimated culture, hybrid strains such as Alcaligenes sp. strain A7-2 were detected, which are more competitive than Pseudomonas sp. strain B13 with respect to chlorophenol degradation. (Author's abstract)
W84-02615

WASTEWATER REUSE IN MUSLIM COUNTRIES: AN ISLAMIC PERSPECTIVE,
University of Petroleum and Minerals, Dhahran (Saudi Arabia). Dept. of Civil Engineering.
S. Farooq, and Z. I. Ansari.
Environmental Management, Vol. 7, No. 2, p 119-123, March, 1983. 3 Ref.

Descriptors: *Water reuse, *Wastewater renovation, *Social aspects, Religious law, Islam, Wastewater treatment.

Recycling wastewater seems to have become a highly useful technique for meeting the shortage of fresh water in all parts of the world. It seems all the more important for Muslim countries because a large number of these countries face acute fresh water shortage. This paper views the problem from an Islamic viewpoint, that is, in the light of the Quran, the Sunnah, and Fiqh works. In Islamic law, water is classified into three categories of tahur, tahir, and mutanajiis. The last two categories can be transmuted into tahur water and thus may be used for all mundane as well as religious purposes if they are assimilated into the overall supply of tahur water. This would be lawful from the Islamic viewpoint even without treating the water. To make use of modern technology in order to recycle wastewater effluents after treatment seems quite in keeping with the spirit and letter of the Islamic teachings. (Author's abstract)
W84-02640

SECONDARY UTILIZATION OF TRACE ORGANICS BY BIOFILMS ON POROUS MEDIA,
California State Water Resources Control Board, Sacramento.
R. G. Stratton, E. Numkung, and B. E. Rittmann.
Journal of the American Water Works Association, Vol. 75, No. 9, p 463-469, September, 1983. 12 Fig, 5 Tab, 25 Ref.

Descriptors: *Organic compounds, *Water treatment, *Biofilms, Secondary utilization, Water reuse, Reclaimed water, Biofilm reactors.

In water reuse schemes as well as in natural biofilm processes are potentially important for the removal of trace levels of organic compounds. The mechanism of secondary utilization in controlled biofilm reactors is described. Secondary utilization is the biodegradation of a secondary substrate. The metabolism of this secondary substrate is inconsequential to sustaining the cells. Trace levels of organics are good examples of secondary substrates. Their concentrations are too low to support any significant cell mass. Experiments with five representative compounds demonstrated that secondary utilization can remove organic compounds from water, even when the input concentrations are low. Experimental and theoretical results showed that fractional removals are often increased as the input concentration is reduced. (Baker-IVI)
W84-02671

BIOLOGICAL TECHNOLOGY OF THE TREATMENT OF LEACHATE FROM SANITARY LANDFILLS,
Australian Atomic Energy Commission, Sutherland. Lucas Heights Research Lab.
P. S. Bull, J. V. Evans, R. M. Wechsler, and K. J. Cleland.
Water Research, Vol. 17, No. 11, p 1473-1481, 1983. 4 Fig, 4 Tab, 10 Ref.

Descriptors: *Leachates, *Anaerobic digestion, *Landfills, Biological oxygen demand, Organic carbon, Wastewater treatment, Nitrogen, Free ammonia, Spray irrigation, Wastewater disposal, Lucas Heights Landfill, Sydney, Australia.

Low cost leachate treatment and disposal techniques were investigated for use at the Lucas Heights Regional Landfill Depot, south of Sydney, Australia. The depot covers 55 hectares and accepts waste from commercial, domestic and industrial sources. The total population serviced is 450,000 and approximately 4000 tonnes of waste per week are currently received for disposal. The laboratory-scale treatment was restricted to low cost schemes for treatment of raw leachate to the standard for spray irrigation. The anaerobic biodegradation of pollutants in sanitary landfill leachate is feasible although the process is much slower than its aerobic counterpart. Under the conditions of an average BOD loading (6000 mg/l) and at 4 C, more than 95% of the soluble BOD and essentially all the iron were removed. In addition, over 90% of the nitrogen originally present was converted to free ammonia. The anaerobic processes consumed about 1 mg of phosphorus/g BOD and yielded 100 mg of suspended solids/g BOD consumed. The anaerobic process with phosphate enrichment provided an effluent which had a BOD of 200 mg/l, an iron content of less than 2 mg/l, and a free ammonia content of 700 mg/l, and which is suitable for disposal by spray irrigation or by municipal sewer if available. For discharge to surface waters, ammonia stripping and aerobic polishing is required. The results of the laboratory studies are sufficiently promising to warrant a pilot-scale examination of anaerobic treatment of leachate under field conditions. (Murphy-IVI)
W84-02697

EVALUATION OF A SAMPLER FOR LIQUID EFFLUENTS,
Imperial Chemical Industries Ltd., Brixham (England). Brixham Lab.
F. J. Whitby, D. R. Cottrell, D. C.-W. Lau, and E. Bishop.
Water Research, Vol. 17, No. 11, p 1491-1498, 1983. 3 Fig, 7 Tab, 15 Ref.

Descriptors: *Effluents, *Samplers, Automation, Suspended solids, Wastewater, Oil, Organic compounds.

A design of automatic sampler for liquid effluent streams is described, which is based on the use of a rapidly circulating pumped stream of the liquid effluent. This stream passes through an interceptor vessel from which sub-samples may be taken isokinetically to provide a variety of sample types (e.g. snap, composite, flow-related). This interceptor may be conveniently located and may also be used to hold monitoring probes (pH, ion selective electrodes) which will provide continuous information on the composition of the effluent stream. This sampler system has been evaluated using simulated liquid effluents, chosen to represent cases in which it is difficult to acquire a truly representative sample. The cases chosen were: (a) water containing up to 10,000 mg/l of finely divided inorganic solid; (b) water containing 2000 mg/l of sewage solids (c) water containing dissolved, volatile organic solutes; (d) water containing dispersed oil. In all cases it proved practical to obtain samples which were representative in composition of the liquid being tested; comparison in all cases was with snap samples taken simultaneously from appropriate points in the loop system. The sampler appears to be generally suitable for use with most types of liquid effluents. The several components of the sampler should be constructed of materials which are inert to the effluent. (Author's abstract)
W84-02699

THE TREATMENT OF LEACHATES FROM DOMESTIC WASTES IN LANDFILLS-I; AEROBIC BIOLOGICAL TREATMENT OF A MEDIUM-STRENGTH LEACHATE,
Water Research Centre, Stevenage (England).
H. D. Robinson, and P. J. Maris.
Water Research, Vol. 17, No. 11, p 1537-1548, 1983. 7 Fig, 7 Tab, 23 Ref.

Descriptors: *Landfills, *Leachates, *Biological treatment, *Aerobic treatment, Domestic wastes, Temperature effects, Nitrification, Ammonia, Retention time, Chemical oxygen demand, Biochemical oxygen demand.

A medium-strength leachate from domestic solid wastes in a landfill (COD 5000 mg/l, BOD 3000 mg/l) was treated using aerobic biological processes in continuous-flow, laboratory-scale reactors at low temperatures. Each unit was completely mixed, and mixed liquor was wasted such that solids retention time (SRT) was equal to the hydraulic retention period. At 10 C with addition of phosphate (COD:P less than 100:1) SRT values of 10 days were required to obtain well-clarified effluents, and high removal of BOD (>98%) and COD (>92%). Reduction of temperature to 5 C resulted in adverse effects on settling of sludges

from units with SRT values of less than 10 days, but in other units good removal of organic materials could still be obtained. These units operated successfully with concentrations of mixed liquor volatile suspended solids (MLVSS) of 1450 mg/l, equivalent to a ratio of F/M of 0.21 kg BOD/kg MLVSS /day or less. Removal of ammoniacal nitrogen which took place (influent concentration 80 mg/l as N) resulted from incorporation in biomass, and at SRT values of 10 days no nitrification took place at 5 or 10 C. Higher concentrations of ammonia in influent leachates resulted in ammonia in effluents when the ratio of BOD:N was less than about 100:3.6. Increasing the SRT of units to 20 days resulted in erratic conversion to nitrite, but reduced pH-values and possible simultaneous denitrification caused floating sludges and poorly-clarified effluents. Removal of ammonia is identified as a major problem when treating leachates, and further research is recommended. (Author's abstract)
W84-02702

HIGH-RATE OVERLAND FLOW,
Utah Water Research Lab., Logan.
D. Wightman, D. B. George, J. H. Zirschky, and D. S. Filip.
Water Research, Vol. 17, No. 11, p 1679-1690, 1983. 12 Fig, 4 Tab, 21 Ref.

Descriptors: *Overland flow, *Wastewater treatment, Load distribution, Land disposal, Municipal wastewater, Grasses, Nitrogen removal, Phosphorus removal, Biochemical oxygen demand, Suspended solids.

Recommended loading rates for treating raw domestic wastewater by overland flow are 6.3-15 cm/wk. Information provided in the literature yields little insight regarding the upper range of hydraulic loading rates that could be effectively treated by overland flow. Therefore, field investigations were conducted to evaluate the performance of the overland flow system at overland flow rates from 0.95 cu m/day/m width of slope (13 cm/wk) to 4.15 cu m/day/m (57 cm/wk). Preliminary treated municipal wastewater was pumped to overland flow slopes, each approximately 3.7 m wide and 36.5 m long. The slope of each plot was 2.5%. The cover crop consisted of a mixture of ryegrass, bluegrass and fescue grass. The plots were operated for 2 years at six different hydraulic loading rates. Effluent BOD5 concentration averages varied from 6 to 11 mg/l. The reduction of influent BOD5 concentration ranged from 87 to 93%. Mean effluent suspended solids values were from 6 to 9 mg/l with reductions of influent concentrations of 91-95%. Hydraulic application rate had little effect on percent BOD5 or suspended solids removal. Total phosphorus reductions were minimal at all hydraulic application rates due to limited soil water contact. Ammonia concentration in the effluent ranged from 1 mg/l NH3-N at the 0.95 cu m/day/m (13 cm/wk) applied flow rate to 11.7 mg/l NH3-N at the 4.15 cu m/day/m (57 cm/wk) loading rate. Ammonia and nitrogen reductions decreased as the applied flow rate increased. Consequently, lower overland flow rates are necessary for nitrogen removal. The use of high-rate overland flow could potentially reduce the land necessary for this form of land application, if nutrient removal was not a local concern. (Author's abstract)
W84-02714

BACTERIOLOGICAL, VIROLOGICAL AND CHEMICAL EVALUATION OF A WASTEWATER-AQUACULTURE SYSTEM,
Murray State Univ., KY. Dept. of Biological Sciences.
T. W. Hejkal, C. P. Gerba, S. Henderson, and M. Freeze.
Water Research, Vol. 17, No. 12, p 1749-1755, 1983. 3 Fig, 6 Tab, 17 Ref. EPA grant R8054301.

Descriptors: *Aquaculture, *Biological wastewater treatment, *Bacteria, *Viruses, *Heavy metals, Coliforms, Streptococcus, Carp, Sediments, Wastewater treatment, Salmonella, Arkansas.

Levels of fecal coliforms (FC), fecal streptococci (FS), Salmonella spp and enteric viruses were monitored in the water, sediment and fish in experimental wastewater-fish ponds near Benton, Arkansas, U.S.A. Concentrations of five heavy metals were also monitored in the fish and wastewater. Concentrations of indicator bacteria were reduced by as much as 99.7% through the series of six ponds which had a calculated total retention time of 72 days. Two filter-feeding species of Chinese carp, Hypophthalmichthys molitrix (silver carp) and Aristichthys nobilis (bighead carp), grown in the last three ponds accumulated FC and FS in their digestive tracts and skin at levels as great or greater than in the surrounding water and sediment. Only low levels of FC and FS were found in the fish muscle tissue (maximum of 25 FS per 100 g) even when concentrations of bacteria in the gut exceeded 105 per 100 g. Concentrations of bacteria in the water and sediment were not good predictors of concentrations in the fish. No Salmonella and no enteric viruses were isolated from the fish, but this lack of isolates was attributed to the extremely low levels which were present in the influent wastewater. Higher levels of copper and mercury were found in the fish flesh than in the surrounding water, with three of eleven fish samples containing higher than acceptable levels of mercury in the edible portion. Based on the efficiency of wastewater treatment, an aquaculture system using silver and bighead carp was judged to be a viable treatment system for domestic sewage resulting in a product suitable for animal or human consumption if proper precautions are taken in harvesting and processing the fish. (Author's abstract)
W84-02719

COMBINED GAMMA-RAY IRRADIATION-ACTIVATED SLUDGE TREATMENT OF HUMIC ACID SOLUTION FROM LANDFILL LEACHATE,
Tokyo Metropolitan Isotope Research Center (Japan).
M. Yamazaki, T. Sawai, T. Sawai, K. Yamazaki, and S. Kawaguchi.
Water Research, Vol. 17, No. 12, p 1811-1814, 1983. 3 Fig, 2 Tab, 9 Ref.

Descriptors: *Irradiation, *Landfill leachates, *Activated sludge process, *Gamma-rays, *Humic acids, Leachates, Wastewater treatment, Microbial degradation, Biodegradation.

Humic acid, which is a typical microbially refractory organic substance, was extracted from a landfill leachate. The humic acid solution (COD = 367 mg/l; TOC = 293 mg/l; BOD = 27 mg/l), after the modification of its biodegradability by gamma-ray irradiation, was applied to a batch scale activated sludge treatment. The BOD increased to 64 mg/l by irradiation of 15 kGy (1.5 Mrad), while the COD and TOC decreased to 231 and 230 mg/l, respectively. When the irradiated sample was treated with an activated sludge, the BOD decreased rapidly in 2-3 h to about 15 mg/l which was a similar value as the unirradiated sample was treated. The elimination efficiency of TOC by the sludge treatment was approximately equal to that obtained by irradiation of 15 kGy. These facts suggest a utility of applying microbial processes after radiation treatment of microbially refractory wastewaters. (Author's abstract)
W84-02724

FORMATION OF ORGANIC CHLORINE IN ACTIVATED SLUDGE EFFLUENTS,
Purdue Univ., Lafayette, IN. School of Civil Engineering.
M. K. Koczwara, E. J. Kirsch, and C. P. Leslie Grady, Jr.
Water Research, Vol. 17, No. 12, p 1863-1869, 1983. 1 Fig, 5 Tab, 25 Ref. NSF grant CME-77-12649.

Descriptors: *Chlorination, *Effluents, *Chlorinated hydrocarbons, Activated sludge process, Wastewater treatment, Dissolved oxygen, Breakpoint chlorination, Organic compounds.

Bench scale activated sludge reactors with a solids retention time of 9 days were operated at all combinations of two levels of pH, dissolved oxygen (DO) concentration and feed type (pH 6 and 8; DO 1 and 7 mg/l; simple and complex feed). Long-term composite samples were collected and adjusted to neutral pH and equal concentrations of alkalinity and ammonia nitrogen. They were then breakpoint chlorinated with NaO(36)Cl in order to determine how much chlorine was incorporated into the organic matter. The amounts ranged from 0.019 to 0.067 mg atomic chlorine incorporated per mg soluble organic carbon. Analysis of variance revealed that the DO concentration was the only independent variable to have a significant effect upon the amount of chlorine incorporated, with reactors operated at high DO levels generally producing effluent organics which were less susceptible to adding chlorine. (Author's abstract)
W84-02728

THE REMOVAL OF MERCURY(II) FROM DILUTE AQUEOUS SOLUTION BY ACTIVATED CARBON,
Delaware Univ., Newark. Dept. of Civil Engineering.
C. P. Huang, and D. W. Blankenship.
Water Research, Vol. 18, No. 1, p 37-46, 1984. 12 Fig, 21 Ref. EPA grant R8081401.

Descriptors: *Mercury, *Activated carbon, *Wastewater treatment, Adsorption, Hydrogen ion concentration, Reduction, EDTA.

The results of preliminary screening tests comparing the total Hg(II) removal capacity of 11 different brands of commercial activated carbon indicated that a very high percent (99-100%) total Hg removal was attained by all types of activated carbon especially at pH 4-5; the percent total Hg(II) removal decreased with pH's >< 4-5 except activated carbons Nuchar SA and SN which maintained a relatively high percent (>90%) total Hg(II) removal capacity at all pH values. Experiments were then conducted to reveal the mechanisms of Hg(II) removal by Nuchar SA (a powdered carbon). The results show that total Hg(II) removal was brought by two mechanisms; the adsorption and reduction. In order to investigate the kinetics of these two reactions, volatilization by bubbling N2 gas at high flow rate was used to remove the Hg(g) product of the reduction reaction. It was noted that both the adsorption and the reduction/volatilization reactions were highly pH-dependent; at pH approximately <3-4 or > approximately 9-10 the extent of reduction/volatilization reaction superceded the adsorption reaction; whereas in the mid-pH region adsorption reaction dominated the total Hg(II) removal. The rate of adsorption reaction is very fast, reaching equilibrium in a few minutes; the rate of reduction/volatilization follows a linear square root of t expression. The reduction reaction is more significant with Filtrasorb 400 (H-type carbon) than Nuchar SA (L-type carbon). In the presence of strong chelating agent, ethylenediaminetetraacetate (EDTA), the total Hg(II) removal decreases due partly to the formation of less adsorbably mercuric(II)-EDTA complexes. (Author's abstract)
W84-02739

ELECTRODEPOSITION OF SIX HEAVY METALS ON RETICULATED VITREOUS CARBON ELECTRODE,
Manitoba Univ., Winnipeg. Dept. of Civil Engineering.
I. C. Agarwal, A. M. Rochon, H. D. Gesser, and A. B. Sparling.
Water Research, Vol. 18, No. 2, p 227-232, 1984. 5 Fig, 3 Tab, 16 Ref.

Descriptors: *Electrodeposition, *Heavy metals, *Reticulated viteous carbon, Electrodes, Industrial wastes, Wastewater treatment, Effluents, Metal-finishing wastes, Copper, Cadmium, Chromium, Lead, Uranium, Zinc.

Metal-bearing liquid effluents resulting from electroplating and other metal processing industrial operations may not be discharged into public sewers as toxic metals interfere with biological treatment systems and restrict the use of biological

sludges. Among the treatment methods available for the removal of these toxic metals at the source, electrodeposition on suitable electrodes is a promising method. Six heavy metals, copper, cadmium, chromium, lead, uranium and zinc were deposited on cathodes made of a newly developed form of carbon, Reticulated Vitreous Carbon (RVC), in a laboratory scale electrochemical reactor. It was possible to electroplate all the six metals from very dilute aqueous using RVC electrodes. Copper deposited 100% at a flow rate of 0.24 cm/min in a single pass while it would require a maximum of 20 passes for 100% chromium deposition at a flow rate of 1.8 cm/min, initial concentrations for both metals being 50 micro mol/l. An increase in flow rate results in a lower percentage of electrodeposition. Experiments conducted using 0.0005 M CuSO4 in 0.5 M Na2SO4 supporting electrolyte resulted in a mass transfer coefficient of the order of 10 to the -3 cm/s and a current efficiency of 64% for the electrodeposition of copper at a cell voltage of 4.0 V. Because of very high porosity, 97%, high specific surface area, up to 66 sq cm/cu cm for RVC grade 100, and useful electrochemical characteristics, RVC can be advantageously used as electrode material for heavy metal removal from dilute industrial effluents. (Moore-IVI)
W84-02750

THE INFLUENCE OF TRANSIENT TEMPERATURE CHANGES ON THE BIODEGRADATION OF NITRILOTRIACETIC ACID IN THE ACTIVATED SLUDGE PROCESS: A PILOT PLANT STUDY,
Imperial Coll. of Science and Technology, London (England). Dept. of Civil Engineering.
T. Stephenson, J. N. Lester, and R. Perry.
Environmental Pollution (Series A), Vol. 32, No. 1, p 1-10, 1983. 2 Fig, 33 Ref.

Descriptors: *Nitrilotriacetic acid, *Activated sludge process, *Biodegradation, Heavy metals, Wastewater treatment, Detergents, Temperature.

Nitrilotriacetic acid (NTA) has been suggested as an alternative detergent builder to sodium tripolyphosphate. NTA used in detergents will reach wastewater treatment plants via the sewerage system. A series of experiments were undertaken using an activated sludge pilot plant treating settled sewage to determine the effects of transient temperature changes on the biodegradation of NTA. The temperature reductions were carried out at two different concentrations of influent heavy metals. Temperature reductions from 17.5 C to 10 C caused a slight decrease in NTA removal. The decrease in NTA removal was more significant during temperature changes from 17.5 C to 7.5 C. Temperature reductions from 17.5 C to 6 C resulted in a substantial decrease in NTA removal. Concentrations of NTA in the effluent attained higher values in experiments with high influent metals concentrations than in comparable experiments with low influent metals concentrations. During cold weather, NTA removal in sewage treatment plants may be impaired, and increased concentrations of NTA in the effluent may be discharged to the receiving waters. (Moore-IVI)
W84-02782

FACTORS AFFECTING THE FATE AND BEHAVIOUR OF TOXIC ELEMENTS IN THE ACTIVATED SLUDGE PROCESS,
Imperial Coll. of Science and Technology, London (England). Dept. of Civil Engineering.
S. Kempton, R. M. Sterritt, and J. N. Lester.
Environmental Pollution (Series A), Vol. 32, No. 1, p 51-78, 1983. 11 Fig, 9 Tab, 64 Ref.

Descriptors: *Activated sludge process, *Metals, *Sludge age, Heavy metals, simulation, Wastewater treatment, Effluents, Suspended solids, Chemical oxygen demand, Particulates, Mixed liquor.

Laboratory simulations of the activated sludge process have been used to study the removal efficiencies of toxic elements over a range of sludge ages. Two laboratory-scale activated sludge simulations were supplied with a synthetic sewage, and operated at six sludge ages from 3 to 18 days. Sixteen elements (Ag, As, Bi, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sb, Sn, Tl, V, Zn) were added continuously to one simulation at nominal influent concentrations considered to be typical of an industrial domestic sewage. The second simulation was operated without the addition of toxic elements. The removals of As, Sb, Co, V and Mn were minimal, while those of Ni, Tl, Zn, Cu, Cr and Pb were moderate (up to 50%), and those of Mo, Bi, Cd, Ag and Sn were substantial (50% to 100%). Optimum removals of Cu, Pb and Bi occurred at a sludge age of 12 days, those of Ni and Cr at a sludge age of 9 days and those of Mo and Zn at a sludge age of 6 days. The optimum removal of Cd appeared to occur at a sludge age of 3 days, although an almost equally high removal occurred at a sludge age of 12 days. Mixed liquor and effluent suspended solids and effluent chemical oxygen demand are the primary factors controlling the removal of most toxic elements. The partition of toxic elements appeared to be between the soluble phase and association with particles of greater than 20 micro m in diameter for both effluent and mixed liquor samples. (Moore-IVI)
W84-02783

A PROGRAM TO ELIMINATE INCREMENTAL WATER POLLUTION FROM A MILL EXPANSION,
Mead Corp., Chillicothe, OH.
W. L. Lapp, K. C. Ayers, and J. L. Parr.
Tappi Journal, Vol. 66, No. 12, p 38-41, December, 1983. 1 Fig, 3 Ref.

Descriptors: *Wastewater treatment, *Pulp and paper industry, Michigan, Escanaba River, Lake Michigan, Cooling towers, Clarifiers, Recycling, Settling basins, Wastewater renovation.

Major expansion projects were carried out in mid-May of 1982 so that the Escanaba Mill would have a significantly increased capacity to produce white papers. The expansion included the addition of a giant new paper machine producing 200,000 metric tons/yr of publishing-type papers, a new 272,000 kg/h combination wood-and-coal fired boiler, expanded groundwood pulping facilities and expanded raw water and wastewater treatment facilities. In order to achieve the necessary 10 million gal/day reduction from the existing mill, big loop recycling was chosen. This involves separating the paper machine sewers from the coating and pulp mill sewers. During expansion the wastewater treatment plant was extensively modified and expanded. The two existing primary clarifiers were separated so that one received paper machine effluent and the other received kraft mill and coating effluents. The bleach-plant acid effluent was rerouted to bypass the primary clarifiers. The first aerated settling basin is now used as a surge basin to equalize BOD concentrations and remove a portion of the BOD, producing a more constant BOD loading going to the activated sludge plant. The second basin has been converted to an unaerated stabilization basin to provide effluent polishing prior to discharge. (Baker-IVI)
W84-02914

APPLICATIONS OF REVERSE OSMOSIS TO COMPLEX INDUSTRIAL WASTEWATER TREATMENT,
Manhattan Coll., Bronx, NY. Dept. of Chemical Engineering.
C. S. Slater, R. C. Ahlert, and C. G. Uchrin.
Desalination, Vol. 48, No. 2, p 171-187, October, 1983. 1 Tab, 97 Ref.

Descriptors: *Reverse osmosis, *Industrial wastewater, *Wastewater treatment, Chemical wastewater, Textile wastewater, Electrochemical wastewater, Pulp wastewater, Food industries wastewater, Groundwater pollution, Surface water pollution, Water pollution control.

Methods for treatment of hazardous and complex, aqueous industrial wastes are of great current interest. Reverse osmosis (RO) is an efficient and cost effective process step for renovation of a broad range of complex industrial wastes. The success of RO in large-scale desalination and municipal wastewater treatment has led many industries to view this technology as a means of pollution abatement and cost savings through reuse. Applications include renovation of effluents from the chemical, textile, petrochemical, electrochemical, pulp, paper and food industries. Also, treatment of landfill leachate with RO is showing promise as a means of avoiding groundwater and surface water contamination. (Murphy-IVI)
W84-02930

STABILITY CONSTANTS AND COMPLEXATION CAPACITIES OF COMPLEXES FORMED BETWEEN HEAVY METALS AND EXTRACELLULAR POLYMERS FROM ACTIVATED SLUDGE,
Imperial Coll. of Science and Technology, London (England). Dept. of Civil Engineering.
T. Rudd, R. M. Sterritt, and J. N. Lester.
Journal of Chemical Technology and Biotechnology, Vol. 33A, No. 7, p 374-380, October, 1983. 4 Fig, 2 Tab, 33 Ref.

Descriptors: *Activated sludge process, *Heavy metals, *Complexation, *Polymers, Chemical reactions, Wastewater treatment, Stability constants, Copper, Nickel, Cadmium, Cobalt, Fulvic acid.

Conditional stability constants and complexation capacities of extracellular polymers extracted from activated sludge with copper, nickel, cadmium and cobalt have been determined at high and low free metal concentrations using gel complexometry. The purpose of the study was to estimate the contribution of the bacterial extracellular polymer to overall metal removal in the activated sludge process. The conditional stability constants obtained for activated sludge extracellular polymer compare well with those previously determined for extracellular polymer extracted from a capsulated wastewater microorganisms, although the Klebsiella aerogenes polymer exhibited a lower affinity for nickel. The sludge polymer constants appear slightly higher than those for peat fulvic acid, and between three and five orders of magnitude higher than those for fulvic acid extracted from sewage sludge. The complexation capacity of the sludge polymer is comparable with that of other biopolymers. The capacity of the sludge polymer to remove metals during the activated sludge process also depends on its degree of solubility, as metals are only removed if they are settled out with the biomass in the final clarifiers. (Baker-IVI)
W84-02933

5E. Ultimate Disposal Of Wastes

FACTORS AFFECTING THE RELEASE OF TRACE METALS FROM MUNICIPAL SLUDGE ASHES,
Notre Dame Univ., IN. Dept. of Civil Engineering.
T. L. Theis, and L. E. Padgett.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1271-1279, October, 1983. 4 Fig, 9 Tab, 42 Ref. EPA grant R806690.

Descriptors: *Trace metals, *Sludge, *Leaching, *Ashes, Activated sludge processes, Aluminum, Calcium, Iron, Phosphorus, Arsenic, Sludge dewatering.

The physical and chemical properties of a variety of incinerated municipal sludge ashes and the corresponding dewatered sludges were investigated with respect to the release of trace inorganics to aqueous solution. The results of single-reagent and series-extraction tests suggest a model of sludge ash surfaces in an aqueous environment. The surfaces of these ash particles very likely display a mosaic pattern of dominant minerals which also exists with depth into the particles. These minerals dominate the solution chemistry, controlling such factors as pH and major ionic concentrations. Although discreet trace minerals or coprecipitates may exist in the ashes, it is suggested that their solubility in an aqueous environment is controlled by surface bonding primarily to inorganic mineral phases. This bonding is strongly pH-dependent as is typical of such surface. The addition of Fe(III)

and/or Al(III) salts tends to partition metals from organic to inorganic forms in raw sludges. The inorganic fractions of Fe and Al become more crystalline on incineration, which acts to increase the leachability of metal cations (with the exception of Cd) if Fe and Al salts have been added during treatment. If these salts are not added, the leachability of cations decreases as a result of incineration. Arsenic behaved inversely to cationic elements. It was less easily leached from both dewatered sludge and ash in the EPA-EP test when Fe and Al have been added. However, in the IAEA test, where pH is allowed to vary, consistently the greatest total amount of As was removed from sludge ashes. (Baker-IVI)
W84-02596

CHEMICAL COMPOSITION AND POSSIBLE MUTAGENICITY OF MUNICIPAL SLUDGES,
Missouri Univ.-Columbia. Environmental Trace Substances Research Center.
For primary bibliographic entry see Field 5A.
W84-02606

WASTEWATER AND SLUDGE MANAGEMENT IN JAPAN,
C. G. Golueke.
BioCycle, Vol. 24, No. 2, p 44-47, March/April, 1983. 2 Fig, 4 Tab, 7 Ref.

Descriptors: *Sludge disposal, *Land application, Japan, Chemical characteristics, Environmental effects, Water pollution control, Tokyo, Yokohama.

Progress is rapid in Japan concerning improvement of the quality of urban and rural environment and the conservation of the nation's resources, particularly its land and water resources. Ideas presented at a conference on land application of sewage sludge held in Tokyo are presented along with opinions from various Japanese officials and professionals. In 1980 the volume of sewage sludge to be disposed of was estimated to have been 2,400,000 cubic meters. About 2,000,000 cubic meters was in the form of dewatered sludge with 230,000 cubic meters in ash, 16,000 cubic meters as dried and composted sludge, and 180,000 cubic meters as thickened or digested sludge. About 42% of the sludge was landfilled, 36% used in land reclamation, 15% used in agriculture, and 7% incinerated or disposed of in some manner. In spite of the heavy industrialized nature of the Tokyo-Yokohama area, the sludge generated in the area's sewage treatment plants has a relatively low toxic metal concentration. Considerable attention is currently being given to composting of sewage sludge. In the operation of the composting unit, sludge cake (70% moisture) is discharged from a storage tank into a mixing unit, in which sludge cake is crushed and blended with a part of the compost discharged from the composter tank. Mention is made of the public agencies responsible in large part for the impressive progress made in wastewater management and sludge utilization in Japan. (Baker-IVI)
W84-02619

SPRAY IRRIGATION WITH LANDFILL LEACHATE,
Idaho Univ., Sandpoint. Research and Extension Center.
H. A. Menser, W. M. Winant, and O. L. Bennett.
BioCycle, Vol. 24, No. 3, p 22-25, May/June, 1983. 1 Fig, 4 Tab, 12 Ref.

Descriptors: *Spray irrigation, *Leachates, *Landfills, Water pollution sources, Water pollution control, Calcium, Sodium, Potassium, Magnesium, Iron, Manganese, Aluminum, Zinc, Strontium, Phosphorus, Copper, Nickel, Lead, Chromium, Cobalt, Cadmium, Metals, Chemical composition, Waste dumps, Wastewater treatment.

A spray irrigation system was used to test the feasibility of decontaminating wastewater by applying sanitary landfill leachate to forest and grass ecosystems. Foliar analysis of the grass species harvested in 1978 revealed no trends toward long-term adverse effects of leachate on the hazardous element constituency of plants. Interim studies showed that Mn levels in most species increased substantially as compared with baseline concentrations. The decline in the loadings of this element and the shift from an acid to a more neutral soil reaction are probably related to a return to low foliar Mn contents. Iron nutrition in these grasses generally has shown trends similar to Mn. Foliar Cl, K, and Na have remained consistently above baseline amounts since the first leachate irrigations. Chloride and Na are relatively mobile ions with low clay attenuation and usually are lost to deep percolation. The persistence of elevated foliar concentrations of these elements suggests that recycled plant residues may contribute to this enhancement. Forage yields have been consistently higher in plots treated in 1974 with superphosphate. Cool-season grasses have shown significantly greater growth in lime and rock phosphate-amended soils as compared with soils that were not fertilized. Bromegrass never became well established and had been eliminated from plots by 1978. Bermudagrasses generally have become well established and grew better with soil amendments. (Baker-IVI)
W84-02620

THE FORMS OF COMBINATION OF CU AND ZN IN DIGESTED SEWAGE SLUDGE,
Oxford Univ. (England). Dept. of Agricultural Science.
A. Baldwin, T. A. Brown, P. H. T. Beckett, and G. E. P. Elliott.
Water Research, Vol. 17, No. 12, p 1935-1944, 1983. 1 Fig, 10 Tab, 35 Ref.

Descriptors: *Sludge, *Copper, *Zinc, Minerals, Plant tissues, Calcium, Iron, Phosphorus, Sulfur, Anaerobic digestion, Hydrogen peroxide.

Digested sewage sludge may be resolved into its principal components by dispersion and sedimentation in water. It contains mineral grains, flakes of micaceous materials, and large and small fragments of plant tissue. Some of these support precipitated compounds of Ca, Fe, P and S. In the samples examined most of these precipitates also contained Cu and Zn. The three samples of sewage sludge produced by the anaerobic digestion of raw primary sludge were collected at different periods. One sample came directly from the digestor, while two were taken from the post-digestion storage tanks. The particles are embedded in a brown matrix comprising fine mineral grains (mainly silica and kaolinite) and microbial detritus, much of which is soluble in acid detergent or in 5M H_2O_2. The matrix is ferruginous and contains inorganic precipitates, including calcium phosphate and possibly a zinc silicate. Chemical analysis and electron microprobe find Cu and Zn in every fraction (except the micaceous material) but they are particularly associated with the components that are destroyed by H_2O_2. (Moore-IVI)
W84-02735

AN ANALYSIS OF REGULATIONS: THEIR IMPACT ON EFFLUENT MANAGEMENT THROUGH PROCESS CONTROL,
National Council of the Paper Industry for Air and Stream Improvement Inc., New York.
For primary bibliographic entry see Field 6E.
W84-02913

5F. Water Treatment and Quality Alteration

USE OF SURFACE WATER FOR REARING CHANNEL CATFISH IN PONDS,
Fish Farming Experimental Station, Stuttgart, AR.
For primary bibliographic entry see Field 6D.
W84-02510

DISINFECTION OF AMOEBIC CYSTS IN WATER WITH FREE CHLORINE,
A. J. Rubin, J. P. Engel, and O. J. Sproul.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1174-1182, September, 1983. 5 Fig, 3 Tab, 38 Ref. EPA grant R-808150.

Descriptors: *Amoebic cysts, *Disinfection, *Chlorination, *Naegleria, Protozoa, Water treatment, Public health, Pathogenic protozoa.

The inactivation of Naegleria gruberi cysts by chlorine was investigated. The non-pathogenic N. grugeri was used because of its close taxonomic relation to N. fowleri and Acanthamoeba, which are major human waterborne pathogenic protozoa. Studies on the rate of inactivation were carried out to determine 99% cyst inactivation at 25 C. Chlorine concentration and pH were measured initially and at convenient intervals. Residuals were also measured. A general pattern of cyst inactivation was noted. At the beginning of the contact period there was a lag during which cyst inactivation was very slow. Following this initial period, the rate of cyst die off increased greatly and the plots of the logarithm of the fraction of cysts surviving against time were essentially linear. At pH 5 the chlorine residuals ranged from 0.45 to 2.64 mg/L-Cl_2 with 99% kill times of 15.8 and 2.78 minutes, respectively. Initial chlorine concentrations, measured before adding cysts, were essentially identical to the respective residual concentrations. At pH 7 chlorine residuals ranged from 0.64 to 3.42 mg/L-Cl_2 with 99% kill times of 21.5 and 2.9 minutes, respectively. Slightly higher levels of chlorine were needed to effect the same level of inactivation at the higher pH. (Baker-IVI)
W84-02587

SUSCEPTIBILITY OF LEGIONELLA PNEUMOPHILA TO CHLORINE IN TAP WATER,
Pittsburgh Dept. of Water, PA.
J. M. Kuchta, S. J. States, A. M. McNamara, R. M. Wadowsky, and R. B. Yee.
Applied and Environmental Microbiology, Vol. 46, No. 5, p 1134-1139, November, 1983. 3 Fig, 3 Tab, 31 Ref. PHS grant AI 17047.

Descriptors: *Legionella, *Chlorination, *Disinfection, *Coliforms, Water treatment, Public health, Water distribution, Water temperature, Plumbing.

Legionellae in a public water supply system are exposed to chlorine concentrations adjusted to control the presence of the indicator coliform bacteria. A study was conducted to compare the susceptibility of legionellae and coliforms to disinfection by chlorine. The chlorine residuals used were similar to concentrations that might be found in the distribution systems of large public potable water supplies. The effects of various chlorine concentrations, temperatures, and pH levels were considered. A number of different Legionella strains, both environmental and clinical, were tested. Legionellae are much more resistant to chlorine than are coliform bacteria. At 21 C, pH 7.6, and 0.1 mg of free chlorine residual per liter, a 99% kill of L. pneumophila was achieved within 40 min, compared with less than 1 min for Escherichia coli. The observed resistance is enhanced as conditions for disinfection become less optimal. The required contact time for the removal of L. pneumophilia was twice as long at 4 C than it was at 21 C. These data suggests that legionellae can survive low levels of chlorine for relatively long periods of time. This supports the hypothesis that small numbers of legionellae may pass through public water supplies and subsequently contaminate internal plumbing systems. (Moore-IVI)
W84-02617

METHODS FOR TESTING THE EFFICACY OF ULTRAVIOLET LIGHT DISINFECTION DEVICES FOR DRINKING WATER,
Health and Welfare Canada, Ottawa (Ontario). Health Protection Branch.
R. S. Tobin, D. K. Smith, A. Horton, and V. C. Armstrong.
Journal of the American Water Works Association, Vol. 75, No. 9, p 481-484, September, 1983. 2 Fig, 3 Tab, 16 Ref.

Descriptors: *Disinfection, *Drinking water, Ultraviolet light, Potable water, Water treatment, Water analysis.

Test protocols were sought that could be used to ensure adequate disinfection under adverse conditions of raw drinking water at the point of use through ultraviolet light devices, particularly in the presence of turbidity and color in the water. The test protocol as developed for fail-safe light sensors uses a color or turbidity agent in the feed solution to reduce the ultraviolet dosage to the established minimum limit in order to determine whether the fail-safe device is properly calibrated and functional. Three commercial UV devices were tested by this method. One device was satisfactory, the second unit was set too low by a factor of 1.6, and the third unit was set low by a factor greater than 2. (Baker-IVI)
W84-02673

REMOVING TRIHALOMETHANE PRECURSORS FROM VARIOUS NATURAL WATERS BY METAL COAGULANTS,
Arizona Univ., Tucson. Dept. of Civil Engineering.
P. A. Chadik, and G. L. Amy.
Journal of the American Water Works Association, Vol. 75, No. 10, p 532-536, October, 1983. 8 Fig, 4 Tab, 18 Ref. NSF grant CHE-8006845.

Descriptors: *Water treatment, *Coagulation, *Natural waters, Trihalomethanes, Alum, Ferric chloride, Chlorides, Organic compounds.

Coagulation of natural waters with alum and ferric chloride proved to be a viable method of trihalomethane control that did not sacrifice effective turbidity removal. The process is particularly attractive for water treatment systems with existing coagulation facilities, precluding large capital expenditures for new processes. The effectiveness of metal coagulation is strongly influenced by process variables, such as coagulant type, coagulant dosage, pH modification, and coagulant aids, as well as raw water characteristics, including TOC, turbidity, alkalinity, ambient pH, and UV absorbance. The bromide ion in natural waters with a trihalomethane formation potential produces brominated trihalomethanes that may greatly contribute to the total trihalomethane formation potential. Brominated haloforms were not reduced by coagulation in the same proportion as chloroform. Caution must be exercised in using TOC and UV absorbance to predict the trihalomethane formation potential of treated and untreated waters. (Baker-IVI)
W84-02675

REMOVING URANIUM FROM DRINKING WATER BY METAL HYDROXIDES AND ANION-EXCHANGE RESIN,
Oak Ridge Operations Office (AEC), TN. Research and Development Div.
S. Y. Lee, and E. A. Bondietti.
Journal of the American Water Works Association, Vol. 75, No. 10, p 536-540, October, 1983. 6 Fig, 2 Tab, 15 Ref. EPA/DOE contract W-7405-eng-26.

Descriptors: *Uranium, *Water treatment, Drinking water, Potable water, Coagulation, Lime, Anion exchange.

Bench-scale testing on uranium removal from a natural water body is described. The water used was chosen as a representative sample of uranium bearing waters. The findings suggest that conventional coagulant and lime softening treatment removes more than 85% of dissolved uranium when an optimum pH and dosage were provided. A strong base anion-exchange column is recommended as an option for the treatment of private well waters containing uranium at higher than desirable levels. The results of small-column experiments suggest that a commercially available column containing 2.2 kg of anion-exchange resin could treat 1,000,000 liters of water containing 83 micrograms U per liter with less than 1 percent breakthrough in the effluent. Anion exchange is available for treating large volumes of water but would require a large capital investment. Small anion exchange columns, however, should be considered for removing uranium from private wells located in uraniferous strata. (Baker-IVI)
W84-02676

COLIFORMS IN A WATER DISTRIBUTION SYSTEM: A REMEDIAL APPROACH,
Springfield City Water, Light and Power, IL. Water Div.
L. D. Hudson, J. W. Hankins, and M. Battaglia.
Journal of the American Water Works Association, Vol. 75, No. 11, p 564-568, November, 1983. 3 Tab, 17 Ref.

Descriptors: *Water distribution, *Coliforms, *Water treatment, Disinfection, Chlorination, Chloramine, Potassium permanganate, Lime, Hydrogen ion concentration, Alkalinity, Bacteria, Residual chlorine, Flushing, Sediments, Springfield, Illinois.

The apparent passage of chloramine-tolerant coliforms through conventional filters and into the distribution system of Springfield, Illinois, in June 1982 signaled the need for intensive control of both the treatment process and the distribution system. The coliform counts exceeded the state bacteriologic standard, resulting in an order to boil water for 10 days even though no coliforms were detected in samples of finished water. Intensive measures were taken to control bacterial growth in the water treatment process and in the distribution system, with an ultimate goal of preventing the reseeding of the system by chlorine-resistant organisms. Chlorine was applied to the incoming raw water in a sufficient dosage to carry a free chlorine residual of approximately 1.0 mg/l through the clarifiers. A 1-mg/l dosage of potassium permanganate was added to the mixing basin. The feed rate of lime was increased to maintain a caustic alkalinity of at least 8.0 mg/l in the clarifiers. The pH of water in the system generally ranged between 10.1 and 10.5. Chlorine was added to the water before it was filtered to obtain a free chlorine residual of 3.0-5.0 mg/l through the clear wells and into the active parts of the system as it was being purged of coliforms. The distribution system was flushed for eight days to blow off sediment and to move the free chlorine residual into the far reaches of the system. Blowoffs were flushed on mains that might accumulate sediment. Laboratory operations were geared to track the success of each operation and to identify the coliform species that had colonized the system. By March 1, 1983, coliforms in the system appeared to be under control, and the counts were within the safe drinking water standards. (Moore-IVI)
W84-02678

RELATIONSHIPS BETWEEN STANDARD PLATE COUNTS AND OTHER PARAMETERS IN WATER DISTRIBUTION SYSTEMS,
FMC Corp., Newark, DE.
M. A. Goshko, H. A. Minnigh, W. O. Pipes, and R. R. Christian.
Journal of the American Water Works Association, Vol. 75, No. 11, p 568-571, November, 1983. 5 Tab, 9 Ref. EPA grant R 805637.

Descriptors: *Water analysis, *Standard plate count, *Coliforms, Turbidity, Residual chlorine, Water temperature, Water distribution, Water treatment, Bacteria, Water quality.

Standard plate counts (SPCs) of water samples collected from seven small, community systems were tested for correlation with coliform occurrence, turbidity, free chlorine residual, total chlorine residual, and temperature. Significant correlations between SPC and one or more of the other parameters were found for some systems. The significant correlations were sometimes positive and sometimes negative, but no generalizations could be made that would fit data for all systems sampled. There was no indication that coliforms or SPC organisms were entering the distribution system through the treatment plant in large densities in any system studied. No single source of contamination was found in any system. Data from an experimental system in which sewage was injected into the treated water showed a strong ($alpha < 0.01$) positive correlation between SPC and coliform densities. From this, it may be inferred that an increase in SPC for a water distribution system may signal a breakdown in sanitary barriers; but, on the other hand, it may be the result of bacterial contamination by some other mechanism. The effects of the sewage introduction were monitored for a longer time with SPC than with coliform counts. The lack of correlation between SPC densities and other water quality parameters should not be taken as an indication that monitoring of SPC is not warranted. Each water quality parameter provides a unique set of information. (Moore-IVI)
W84-02679

THE REMOVAL OF MANGANESE IN WATER TREATMENT CLARIFICATION PROCESSES,
Southern Water Authority, Worthing (England).
A. Lloyd, R. Grzeskowiak, and J. Mendham.
Water Research, Vol. 17, No. 11, p 1517-1523, 1983. 5 Fig, 1 Tab, 17 Ref.

Descriptors: *Manganese, *Water treatment, *Clarification, *Floc blanket clarifiers, Adsorption, Oxidation, Calcium carbonate, Chlorination, Iron.

The processes that affect manganese removal in floc blanket clarifiers were studied to assist in the design of manganese removal process. Using the extended Debye-Huckel equation and a hydrogen carbonate acidity correction, an adjusted equation for ionic strength of 0.009 M was developed. This in turn revealed that the rate of oxidation of absorbed manganese must exceed the rate of loss of adsorbed manganese in solids discharged from the floc blanket. If this condition is achieved, then the concentration of manganese oxides in the floc blanket will increase. The rate of loss of adsorbed manganese (II) is calculated from the adsorption ratio on hydrated iron(III) oxide (HIO) and the rate of replacement of HIO in the floc blanket. The removal of manganese from ferruginous ground water is determined mainly by pH, iron and manganese concentration and is relatively insensitive to the variation in composition of other cations or anions. When the solution pH approaches 8.5, calcium carbonate may cause cementing of sand grains in the filter presenting a major problem to treatment plant efficiency. Chlorine can be used to oxidize manganese adsorbed onto HIO and thus overcome the problem of calcium carbonate precipitation. The removal mechanisms may be broadly classified as adsorption and oxidation. (Murphy-IVI)
W84-02701

MUTAGENICITY AND ORGANIC SOLUTE RECOVERY FROM WATER WITH A HIGH-VOLUME RESIN CONCENTRATOR,
Los Angeles County Sanitation Districts, Whittier, CA.
For primary bibliographic entry see Field 5A.
W84-02704

EMPIRICAL RATE EQUATION FOR TRIHALOMETHANE FORMATION WITH CHLORINATION OF HUMIC SUBSTANCES IN WATER,
Yokohama National Univ. (Japan). Dept. of Safety and Environmental Engineering.
For primary bibliographic entry see Field 5B.
W84-02723

MULTIVARIATE STATISTICAL RELATIONSHIPS BETWEEN ROUTINE WATER PLANT DATA AND TRIHALOMETHANE LEVELS; IMPLICATIONS FOR STUDIES OF HUMAN HEALTH,
Ohio State Univ., Columbus. Dept. of Preventive Medicine.
N. A. Reiches, and J. R. Wilkins, III.
Water Research, Vol. 17, No. 12, p 1881-1890, 1983. 3 Fig, 6 Tab, 38 Ref. PHS grant CA21751.

Descriptors: *Trihalomethanes, *Chlorination, *Statistical analysis, Public health, Water treatment, Mathematical models, Water temperature, Color, Chloroform, Chlorinated hydrocarbons, Halogenated hydrocarbons, Estimating, Ohio, Columbus.

Routine water treatment plant data from the Dublin Road Water Plant (Columbus, Ohio) were used to construct a mathematical/statistical model

of trihalomethane formation during lime-soda ash softening. Chemical characteristics of the raw water, such as temperature and color, and several treatment parameters, including chlorine dose, were significant predictors for chloroform and total trihalomethanes. The pattern of prediction was notably different for the brominated species. It appears feasible to model with multivariate statistical methods and routine water plant data the formation of trihalomethanes during the disinfection of water with chlorine. The procedure suggests the prospect of estimating, with reasonable accuracy trihalomethane levels in water supplies for past time periods when only the routine water plant data are available. From a health hazard evaluation perspective, this is a most attractive possibility. (Moore-IVI)
W84-02730

GAS CHROMATOGRAPHY IN WATER ANALYSIS-I; ORGANIC PROFILES OF WATER SOURCES,
National Coal Board, Stoke Orchard (England). Coal Research Establishment.
For primary bibliographic entry see Field 5A.
W84-02731

GAS CHROMATOGRAPHY IN WATER ANALYSIS-II; SELECTIVE DETECTION METHODS,
National Coal Board, Stoke Orchard (England). Coal Research Establishment.
For primary bibliographic entry see Field 5A.
W84-02732

REMOVAL OF POLIOVIRUS AND ROTAVIRUS FROM TAPWATER BY A QUATERNARY AMMONIUM RESIN,
Arizona Univ., Tucson. Dept. of Microbiology.
C. P. Gerba, G. E. Janauer, and M. Costello.
Water Research, Vol. 18, No. 1, p 17-19, 1984. 4 Tab, 12 Ref.

Descriptors: *Disinfection, *Poliovirus, *Rotavirus, *Anion exchange resins, Water treatment, Viruses, Potable water.

A quaternary ammonium-type anion exchange resin was tested as a contact water viral disinfectant. Suspensions of tapwater containing approximately 10000 plaque-forming units/ml of poliovirus type 1 and Simian rotavirus SA-11 were passed through 1 ml beds of resin, at flow rates of 10-12 ml/min. With resin 14-1, 91->99.9% of the input virus was removed. The beds were effective in removal of virus even after passage of 1500 ml of tapwater. Less than 10% of the virus associated with resin 14-1 could be recovered as compared to 100% for control resin. Kinetic studies indicated that virus adsorbed to the resins were being inactivated. (Author's abstract)
W84-02737

THE DYNAMICS OF SUSPENDED ALGAL POPULATIONS IN THE LOWER WYE CATCHMENT,
Welsh Water Authority, Powys (Wales).
For primary bibliographic entry see Field 2H.
W84-02738

PRELIMINARY STUDIES ON THE LEACHING OF SOME TRACE METALS FROM KITCHEN FAUCETS,
Health and Welfare Canada, Ottawa (Ontario). Environmental Health Centre.
E. R. Samuels, and J. C. Meranger.
Water Research, Vol. 18, No. 1, p 75-80, 1984. 1 Fig, 4 Tab, 15 Ref.

Descriptors: *Leaching, *Trace metals, *Faucets, *Plumbing fixtures, *Lead, Cadmium, Copper, Zinc, Chromium, Solder, Fulvic, Heavy metals, Ontario, Ottawa.

Preliminary studies were carried out on the leaching of copper, zinc, chromium, cadmium and lead from eight kitchen faucets by samples of raw, filtered and distributed Ottawa water, a sample of well water and deionized water containing 2 mg/l aqueous fulvic acid. Leaching was effected by allowing the test solutions to stand in the inverted faucets for two successive 24-h periods. Concentrations of the metals found in the leachates were copper; first leaching, 0.12-28.0 mg/l, second leaching, 0.08-3.54 mg/l; zinc; first leaching, 0.13-10.25 mg/l, second leaching, 0.06-2.85 mg/l; chromium; first leaching, <0.001-0.395 mg/l, second leaching, <0.001-0.032 mg/l; cadmium; first leaching, <0.0005-0.01 mg/l, second leaching, <0.0005-0.004 mg/l; and lead; first leaching, <0.2-110.0 mg/l, second leaching, < 0.2-82.0 mg/l. The faucets containing lead-soldered copper joints released high concentrations of lead, particularly in the case of leaching with the aqueous fulvic acid solution. In some cases the concentrations of metals leached could lead to intakes in excess of the maximum permissible limits for these metals. The use of lead solder in kitchen faucets, and conceivably in other parts of the distribution system, could result in abnormally high concentrations of lead in the drinking water, especially if humic substances are present even at low levels. (Moore-IVI)
W84-02740

THE INACTIVATION KINETICS OF H-1 PARVOVIRUS BY CHLORINE,
Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemical Engineering.
C. C. Churn, G. D. Boardman, and R. C. Bates.
Water Research, Vol. 18, No. 2, p 195-203, 1984. 17 Fig, 3 Tab, 17 Ref.

Descriptors: *Parvoviruses, *Chlorination, *Disinfection, *Inactivation kinetics, Virus inactivation, Water treatment.

A newly isolated enteric virus has recently been found to be associated with large outbreaks of waterborne gastroenteritis. Most commonly referred to as the Norwalk agent, this virus appears to be morphologically and biophysically similar to the parvoviruses. In this study the parvovirus H-1, a putative human virus containing single-stranded DNA, was used as a model virus for chlorine inactivation experiments. The objective of this research was to investigate the kinetics of inactivation of this virus by low levels of free chlorine (0.05-0.02 mg/l) at pH 7 and at 5, 10, 20 and 30 C. Inactivation occurred in the usual dose-response relationship, that is, increasing the chlorine dose caused an increase in the rate of inactivation. The energy required for the inactivation reaction using 0.05 mg/l free chlorine from 5 to 30 C was graphically determined to be 2.4 kcal/mol. The change in entropy was calculated to be -52.34 entropy units. For disinfection purposes, the time required for 99% inactivation of H-1 parvovirus at pH 7, 20 C and a chlorine dose of 0.2 mg/l free chlorine was 3.2 min. The parvovirus H-1 appeared to be less resistant to free chlorine than poliovirus type 1 (LSc). (Author's abstract)
W84-02748

UPGRADING WATER FILTRATION PLANTS,
Camp, Dresser and McKee, Inc., Boston, MA.
P. W. Prendiville.
Civil Engineering, Vol. 53, No. 10, p 64-67, October, 1983. 4 Fig.

Descriptors: *Water treatment facilities, *Filtration, Chlorination, Ozone, Chlorine dioxide, Trihalomethanes, Disinfection, Coagulation, Flocculation, Sedimentation.

Improvements are being contemplated by many municipalities for their existing water plants. Plant capacity can often be increased by simply adding or improving mixing, flocculation and sedimentation devices, and changing filter media. Formation of trihalomethanes can be reduced in many cases by changing disinfecting chemical application points or by changing from chlorine to ozone, chlorine dioxide, or chloramines. Hydraulics at a plant can be improved by baffling flow. Coagulant chemicals can be changed or optimized, and laminar tubes or trays can be installed in many existing settling basins. Replacing shallow layers of media with dual media often allows for doubling the capacity of a filter. When media are changed, underdrain and backwashing facilities need to be drained. (Baker-IVI)
W84-02774

A RATIONAL EVALUATION OF CANCER MORTALITY ASSOCIATIONS WITH TREATED DRINKING WATER,
Carollo (John) Engineers, Walnut Creek, CA.
J. E. Tiernan.
Journal of Environmental Health, Vol. 46, No. 3, p 118-126, November/December, 1983. 1 Fig, 1 Tab, 45 Ref.

Descriptors: *Drinking water, *Mortality, *Epidemiology, *Carcinogens, Mutagens, Potable water, Water treatment, Statistical studies.

Identification of known and suspected carcinogens and mutagens in potable water supplies in the United States has led to a series of recent epidemiological investigations. Statistically significant correlations between site-specific and sex-specific cancer mortality rates and treated drinking water have been identified in certain regions of the United States. Some apparently contradictory investigations and criticisms have also received attention. Representative investigations were selected for evaluation utilizing a set of five formalized criteria to determine the probability that an epidemiological association is causal or noncausal. Studies which linked the drinking water variable to increased cancer mortality rates exhibited consistency, statistical strength, dose response relationships, and coherence with existing scientific knowledge. Difficulties in establishing causal relationships were due primarily to temporal associations (duration of dose/length of residence), indirect associations, and specificity of the independent water variable. (Author's abstract)
W84-02799

BACTERIOLOGICAL WATER SAMPLING OF PUBLIC WATER SUPPLY SYSTEMS IN LANCASTER COUNTY, NEBRASKA, 1983,
Lincoln-Lancaster County Health Dept., Lincoln, NE. Div. of Environmental Health.
R. R. Marquart.
Journal of Environmental Health, Vol. 46, No. 3, p 132-135, November/December, 1983. 4 Fig, 1 Tab, 14 Ref.

Descriptors: *Sampling, *Drinking water, *Lancaster County, *Nebraska, *Bacteria, Water distribution, Disinfection, Chlorination, Monitoring.

The drinking water monitoring data reported are from public water supply systems in less populated areas of Lancaster County, Nebraska. The field experience from the Lincoln-Lancaster County Health Department and the bacteriological drinking water sampling data from a 6 1/2 year study show that a reduction in flushing time of the sample tap from two minutes to one minute before collecting samples did not increase the number of unsatisfactory samples. The low level of spurious bacteriological water samples (0.49%) during the study indicates that tap disinfection, removing aerators from taps, and lengthy tap flushing time are unnecessary. Reducing the flushing time before collecting samples also results in an annual savings of approximately 22,000 gallons of water in Lancaster County. Unnecessary restrictive procedures in tap selection are time consuming for field staff. Experience in Lancaster County does not support routine removal of the ubiquitous aerator or avoiding taps threaded for hoses as an effective way to prevent unsatisfactory bacteriological water samples. The Health Depatment recommends continuous disinfection for all public water supply systems, and those maintaining adequate free chlorine residuals always had satisfactory bacteriological water samples. (Moore-IVI)
W84-02800

SIGNIFICANCE OF LOSSES IN WATER DISTRIBUTION SYSTEMS IN INDIA,

National Environmental Engineering Research Inst., Nagpur (India). Environmental Engineering Consultancy Div.
V. Raman.
Bulletin of the World Health Organization, Vol. 61, No. 5, p 867-870, 1983. 3 Tab.

Descriptors: *Water distribution, *India, *Leakage, *Water loss, Water conservation, Cost-benefit analysis, Pipes, Water conveyance.

Effective management of water supply systems consists in supplying adequate quantities of clean water to the population. Detailed pilot studies of water distribution systems were carried out in 9 cities in India during 1971-81 to establish the feasibility of a program of assessment, detection, and control of water losses from supply systems. A cost-benefit analysis was carried out. Water losses from mains and service pipes in the areas studied amounted to 20-35% of the total flow in the system. At a conservative estimate, the national loss of processed water through leaks in the water distribution systems amounts to 1012 liters per year, which is equivalent to 500 million rupees. It is possible to bring down the water losses in the pipe mains to 3-5% of the total flow, and the cost incurred on the control program can be recovered in 6-18 months. Appropriate conservation measures will help in achieving the goals of the International Water Supply and Sanitation Decade to provide clean water for all. (Author's abstract)
W84-02801

AN ESTIMATION OF THE EXPOSURE OF THE POPULATION IN FINLAND TO SUSPECTED CHEMICAL CARCINOGENS,
Institute of Occupational Health, Helsinki (Finland).
K. Hemminki, H. Vainio, M. Sorsa, and S. Salminen.
Journal of Environmental Science and Health, Vol. C1, No. 1, p 55-95, 1983. 6 Tab, 124 Ref.

Descriptors: *Drinking water, *Water quality, *Public health, *Carcinogens, *Finland, Asbestos, Polycyclic aromatic hydrocarbons, Trihalomethanes, Chloroform, Chlorination, Decomposing organic matter.

Information available from Finland was used to estimate the total exposure of the population to compounds suspected of carcinogenicity. Potable water was found to account for daily exposures of less than 1 mg. In Finland the most frequently used source of raw water is surface water. Surface water contains much organic material, most of it naturally occurring humus. Extensive purification and treatment processes are required to guarantee the quality of drinking water. The concentration of some natural compounds and reaction products may reach a level where toxic effects are possible. About 2 million Finns use drinking water with an approximate mean trihalomethane concentration of 0.07 mg/l. The highest concentration found was 1.3 mg/l, due partly to the naturally occurring aquatic humus and eutrophication in Finnish raw waters, and partly to the break-point chlorination practice. In most Finnish studies the sum of the concentrations of polycyclic aromatic hydrocarbons analyzed has been below 200 ng/l, the maximum allowable concentration for these compounds in drinking water. Assuming a 2 liter per capita consumption of drinking water per day, the approximate mean amount of PAHs taken in by the average Finn may be around 0.2 micrograms/day. Since the pipeline material formerly used in Finland has a high content of asbestos, which may dissolve in the drinking water, it is likely that the drinking water contains some asbestos fibers. (Baker-IVI)
W84-02822

THE RISKS OF DRINKING WATER,
Harvard Univ., Cambridge, MA. Energy and Environmental Policy Center.
E. A. C. Crouch, R. Wilson, and L. Zeise.
Water Resources Research, Vol. 19, No. 6, p 1359-1375, December, 1983. 2 Fig, 2 Tab, 50 Ref.

Descriptors: *Carcinogens, *Drinking water, *Public health, Organic compounds, Water pollution effects, Water quality standards.

Current drinking water standards are not directly related to health risks posed. Usually it is cancer risk which is of greatest concern in the setting of guidelines for low levels of organic compounds, and almost always estimates of cancer risk are made in an atmosphere of uncertainty. Current standards for a given chemical or class of chemicals do not account for the present of other pollutants, chemicals which have not been tested in long term oral bioassays are generally ignored, and the uncertainties of risk calculations are not explicitly considered. To better quantify risks from drinking waters, procedures are applied which incorporate measures of uncertainty into the risk calculation and consider all chemicals included in a water analysis. This procedure is demonstrated by calculating risks for 25 U.S. water supplies, based on the EPA National Organic Monitoring Survey of 1976-77. All the cities had average risks greater than 10 to the -6th per year and several had values of 10 to the -5th and above. (Moore-IVI)
W84-02839

COMBINED APPLICATION OF OZONE AND CHLORINE OR CHLORAMINE TO REDUCE PRODUCTION OF CHLORINATED ORGANICS IN DRINKING WATER DISINFECTION,
Beak Consultants Ltd., Mississauga (Ontario).
J. L. Robertson, and A. Oda.
Ozone: Science and Engineering, Vol. 5, No. 2, p 79-93, 1983. 4 Fig, 9 Tab, 16 Ref.

Descriptors: *Ozone, *Chlorine, *Chloramine, *Residual chlorine, *Organic solvents, *Drinking water, *Disinfection, Ozonation, Chlorination, Water quality, Water quality control.

Chlorination of water produces halogenated organics in addition to trihalomethanes. Ozone is examined as the primary disinfectant on water supplies in Ontario containing high concentrations of dissolved organic carbon (DOC), as a means to reduce elevated levels of trihalomethanes (THM). Previous work had indicated that elimination of pre-chlorination leads to reduced THM concentrations. However, the elimination of primary disinfection may lead to problems of bacterial and algal growth as well as to taste and odor problems in water treatment plants with high DOC raw water supplies. Pilot plant studies demonstrated that pre-ozonation coupled with controlled use of post-chlorination led to significant reductions in both THM and non-purgeable organo-halogen (NPOX) compounds. The use of chloramine to provide a residual following pre-ozonation virtually eliminated the formation of THM and NPOX. Batch tests confirmed these conclusions for another high DOC water supply, although the THM and NPOX production per unit of DOC varied between water supplies. The results have significant practical implications for the control of THM and NPOX in drinking water disinfection. (Murphy-IVI)
W84-02905

USE OF OZONE IN THE TECHNOLOGY OF BOTTLED WATER,
Institut Fresenius, Taunusstein (Germany F. R.).
W. Schneider, and H. H. Rump.
Ozone: Science and Engineering, Vol. 5, No. 2, p 95-101, 1983. 2 Fig, 2 Tab, 4 Ref.

Descriptors: *Ozone, *Bottled water, Mineral water, Ozonation, Chemical properties, Sulfur, Iron, Manganese, Arsenic, Alumina, Filtration, Water quality standards, Sterilization.

A review is given on the EC requirements for mineral water and on the analytical examinations necessary for proving its natural purity. Ozone treatment in combination with filtration can remove several undesirable substances without any major alteration of the chemical composition. Such substances would otherwise impede the marketability of a water. Sulfur, iron and manganese are easily oxidized by ozone and the iron and manganese hydroxides are removed by filtration. Arsenic is eliminated by coprecipitation with iron. Fluoride can be largely removed by filtration through alumina. Any off-taste, occasionally caused by natural organic substances, is prevented by the ozone treatment. Additionally, there is the possibility of sterilizing wine bottles with ozone-containing water. (Murphy-IVI)
W84-02906

IMPROVING FILTER MEDIA (ACTIVATED CARBON) BY OXIDATIVE PRETREATMENT WITH OZONE AND PERSULPHATE,
Ecole Nationale Superieure de Chimie de Rennes (France).
K. Gaid, D. Lemarchand, G. Martin, and C. Cavelier.
Ozone: Science and Engineering, Vol. 5, No. 2, p 113-127, 1983. 13 Fig, 6 Tab, 17 Ref.

Descriptors: *Filter media, *Activated carbon, *Pretreatment of water, *Ozone, *Persulfate, Drinking water, Physical properties, Chemical properties, Water pollution control, Porous media.

Treatment of drinking water with activated carbon by oxidation of the carbon altering its physical and chemical properties improves the quality of the water Ozonized carbons are more efficient than non-treated carbons both in physical-chemical and biological treatment. Oxidation is realized by means of two oxidants: ozone or ammonium persulfate. The treatment modifies the distribution of porous volume of carbon, creates surface conditions which appears to affect the rate, the capacity and character of pollutant elimination. Oxidation favors the retention of adsorbable and non-adsorbable compounds (humic substances, phenols, ethanol). (Murphy-IVI)
W84-02907

EXPERIENCES WITH COAGULATIONS AND COAGULANTS,
Dallas City Water Utilities Dept., TX.
R. F. Stone.
Southwest and Texas Water Works Journal, Vol. 65, No. 9, p 17-20, 1983.

Descriptors: *Coagulation, *Water treatment, *Coagulants, Drinking water, Texas, Dallas, Lime, Ferric sulfate, Clarification, Polymers, Turbidity.

Several lake sources provide the raw water for use in the Dallas drinking water supply. Experience there with coagulation has mostly been with ferric sulfate in conjunction with lime softening. While this treatment mode produces a high quality of water under essentially all conditions, it also produces a high quantity of sludge by-product. Prior to 1966 total lime softening had been employed. After 1966 a partial softening was recommended by feeding only sufficient lime to produce a finished water with a total alkalinity of 50 ppm. With the reduction in lime feed, the ferric sulfate coagulation was somewhat less efficient and a higher coagulant dosage was required to properly clarify the water before filtration. The major problem with the partial softening process was in being able to clarify high turbidity storm water runoff which came down the river after heavy rainfalls. Large quantities of waste sludge are produced in this method. Experiments are being conducted using polymers as coagulants. (Baker-IVI)
W84-02910

WATER SUPPLY AND TREATMENT: WHAT MODERN TECHNOLOGY HAS TO OFFER,
G. L. Ingham.
Water and Waste Treatment, Vol. 26, No. 11, p 30-32, November, 1983. 1 Fig.

Descriptors: *Technology, *Water treatment, Economic aspects, Telemetry, Computers, Management, Decision making, Planning.

Various parameters may encourage a manager of a water supply and treatment facility to consider and implement the introduction of new and more sophisticated equipment. Increased efficiency, reductions in manpower, improved reliability, additional management information, lower capital costs, and

reduced waste are some of the parameters which will encourage the use of more modern technology. The two major questions which must be answered involve cost - how much will the changes cost to achieve, and what will be the initial and long-term savings of the project. Considerable pressure will be experienced by those facing the task of making decisions, as the field of manufacture and supply of technological equipment is extremely competitive. An example of one phase of modern technology is offered in the form of a comprehensive telemetry system which has been used to replace a very old-fashioned system of monitoring the water treatment and supply system of a company. (Baker-IVI)
W84-02916

5G. Water Quality Control

BIOLOGICAL CONTROL OF UNDESIRABLE CYANOBACTERIA IN CULTURALLY EUTROPHIC LAKES,
Oslo Univ. (Norway). Zoological Museum.
A. Brabrand, B. A. Faafeng, T. Kallqvist, and J. P. Nilssen.
Oecologia, Vol. 60, No. 1, p 1-5, 1983. 5 Fig, 1 Tab, 20 Ref.

Descriptors: *Oscillatoria, *Nassula, *Biological control, *Eutrophication, Cyanophyta, Nuisance algae, Roach, Cyclops, Model studies, Water temperature, Eutrophic lakes.

The relationship between Oscillatoria agardhii and one of its natural grazers, the gymnostomid ciliate Nassula ornata was studied in laboratory experiments. Ingestion of Oscillatoria by Nassula increased exponentially over the temperature range 5-20 C, and the grazer was able to suppress Oscillatoria at all temperatures. Laboratory studies showed further that the predatory copepod Cyclops strenuus was able to suppress Nassula, and that juvenile roach (Rutilus rutilus) also fed on Nassula. In an enclosure experiment in an Oscillatoria-lake, Nassula reduced Oscillatoria concentration more that 50% as compared to the control. The scarcity of Nassula in many Oscillatoria-lakes may be due to predation by cyclopod copepods and juvenile fish; predominantly cyprinids. A proposed model describes well the population dynamics of Oscillatoria and Nassula in mixed cultures. Predation by crustaceans hampers the prospect of employing Nassula in the biological control of Oscillatoria. However, an introduction of Nassula in sufficient numbers to Oscillatoria-lakes at a time when the population of activity of potential predators is low should be seriously considered as a measure to reduce Oscillatoria blooms. (Moore-IVI)
W84-02493

PHOSPHORUS CONTROL MEASURES PAY OFF IN THE GREAT LAKES,
Michigan Dept. of Natural Resources, Lansing.
J. H. Hartig.
Water Engineering and Management, p 32-35, December, 1983. 5 Fig, 10 Ref.

Descriptors: *Phosphorus, *Great Lakes, *Water quality control, Wastewater treatment, Sludge treatment, Secondary wastewater treatment, Wastewater treatment facilities, Detroit River, Lake Erie, Ontario, Water pollution control, Phosphorus removal, Phytoplankton.

The levels of phosphorus detected in the Detroit River as it moves into Lake Erie have declines by 85% since 1967, most of which is due to phosphorus control efforts made at the Detroit Wastewater Treatment Plant. This 2.5 mgd plant is the largest facility of its kind in the Great Lakes Basin discharging to the Great Lakes, serving over 3 million people. The plant provides activated sludge, secondary treatment to the dry-weather flows of 76 communities. The treatment process includes preliminary treatment, primary treatment incorporating chemical feed for phosphorus removal and sedimentation, activated-sludge secondary treatment, chlorination, and sludge treatment and disposal. A decline in phosphorus concentrations was also noted in the Western Basin, measured at the Union Water Intake in Kingsville, Ontario. This decrease has been about 50% since 1967 and appears to have been the result of a major decline in the North Shore net phytoplankton community. Open lake phytoplankton analyses have also indicated a reduction of total phytoplankton biomass and a shift in species composition toward oligotrophy. (Baker-IVI)
W84-02520

STATISTICAL MODELS FOR WATER QUALITY REGULATION,
Colorado State Univ., Fort Collins. Dept. of Agricultural and Chemical Engineering.
J. C. Loftis, R. C. Ward, and G. M. Smillie.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1098-1104, August, 1983. 1 Tab, 8 Ref. NSF grant PRA-7913073.

Descriptors: *Statistical models, *Water quality control, Water quality, Model studies, Mathematical studies, Probability distribution, Frequency distribution, Stationary process, Seasonal variations, Linear programming, Confidence intervals.

A few statistical methods, simple enough for immediate use by regulatory agencies, are summarized and demonstrated for use in interpreting water quality data in light of current stream standards. The specific statistical techniques include: unconditional probability distribution models, seasonal probability distribution models, linear regression models, and confidence intervals on probability models. The usefulness of models such as the linear regression models lies in their ability to distinguish between natural and artificial causal mechanisms governing water quality processes. All four of the methods may be used by regulatory agencies in an effort to evaluate the significance of water quality changes, particularly standards violations, with regard to the relative importance of natural impacts or artificial impacts on water quality. The choice of which to apply will depend on the individual situation. Each of the four can be applied by personnel with only a limited understanding of statistical theory and only small microcomputers or programmable calculators and needed to perform the required computations on a routine basis. Application of these methods and tools should greatly enhance the ability of routine, fixed-station monitoring to provide in an efficient manner the kind of information needed for implementing the Clean Water Act. (Baker-IVI)
W84-02577

MANAGEMENT OF A GROUNDWATER PROBLEM,
Stollar (Robert L.) and Associates, Cypress, CA.
R. L. Stollar, R. Pellissier, and P. Studebaker.
Journal of the Water Pollution Control Federation, Vol. 55, No. 11, p 1393-1403, November, 1983. 11 Fig, 9 Ref.

Descriptors: *Groundwater pollution, *Water quality control, Resistivity, Plumes, Water pollution sources, Groundwater movement, Phosphates.

The use of resistivity studies and drilling programs facilitated detailed description of the hydrogeologic environment and the geometry of a contaminated groundwater body. A monitoring program was designed and initiated after the drilling program was completed. Interpretation of the data collected during the monitoring program was successfully used to interpret the dynamics of the groundwater system, impacts of pumping, and migration of contaminants within the groundwater system. The results of the field and monitoring program enabled groundwater management, abatement, and control progams to be designed and initiated. It seems that these new programs will control the plume underlying the FMC Corporation Industrial Chemical Group plant and manage the groundwater problem in Lawrence, Kansas. (Baker-IVI)
W84-02604

DIURNAL WATER QUALITY MODELING - A CASE STUDY,
Weston (Roy F.), Inc., West Chester, PA.
A. K. Deb, and D. Bowers.
Journal of the Water Pollution Control Federation, Vol. 55, No. 12, p 1476-1488, December, 1983. 15 Fig, 3 Tab, 4 Ref.

Descriptors: *Water quality control, *Model studies, Dissolved oxygen, Wastewater treatment facilities, Water treatment, Shenandoah River.

Requirements for treatment beyond secondary levels of publicly owned treatment works (POTWs) must now be supported by a calibrated and verified water quality modeling study. In many small streams, diurnal dissolved oxygen fluctuations from photosynthesis are so large that proper mathematical simulation of diurnal variation in the stream is needed. A systematic, rational method has been used to simulate the diurnal changes in DO concentration of a stream. The South Fork of the Shenandoah River has been modelled. Three sets of comprehensive stream surveys were conducted. The DIURNAL model was used to simulate the diurnal behavior of the stream DO. Proper simulation of diurnal DO fluctuations depends largely on the proper evaluation of photosynthetic and respiration rates of aquatic plant communities. After proper calibration and model verification, a rational methodology of wasteload allocation was used to develop various combinations of permissible carbonaceous BOD and nitrogenous BOD wasteloads to meet water quality criteria. The methodology of diurnal DO modelling and wasteload allocation discussed will help practical engineers develop wasteload allocations for streams with high diurnal DO fluctuations. (Baker-IVI)
W84-02607

VARIABLE EFFLUENT NITRIFICATION REQUIREMENTS BASED ON INSTREAM WATER QUALITY,
Black and Veatch, Denver, CO.
R. D. Kuchenrither, C. P. Houck, C. W. Inghram, M. M. Grimes, and G. K. Elmund.
Journal of the Water Pollution Control Federation, Vol. 55, No. 12, p 1489-1496, December, 1983. 5 Fig, 4 Tab.

Descriptors: *Water quality control, *Nitrification, *Effluents, Effluent standards, Fort Collins, Colorado, Ammonia, Nitrogen.

Fort Collins, Colorado, has two wastewater treatment plants that discharge to the Poudre River. Plant 1 has no nitrification requirements and is base-loaded at an annual average rate of 175L/s in the winter and 263L/s in the summer. Plant 2 is located between two major irrigation water diversion ditches, Fossil Creek Ditch and Boxelder Ditch. Plant 2 has an effluent total ammonia nitrogen discharge limit of 4.9 mg/L in summer and winter. To meet this limit, wastewaters must undergo nitrification prior to discharge to the river. The city has demonstrated that a water quality management program consisting of daily manipulation of discharge points represents a viable alternative to nitrification at its wastewater treatment facilities. Under the existing discharge permit, nitrification was required for each of the 680 days analyzed. However, the analysis of actual stream data showed that only on 4 of these 680 days would nitrification have been required to avoid exceeding the 0.10, g/L ammonia-nitrogen limitation in the Poudre River. The program as proposed has the potential to save the citizens of Fort Collins a minimum of about $140,000 annually, and at the same time, to maintain higher flows and assure the protection of the water quality in the river. Under a static discharge permit process currently employed, the simultaneous accomplishment of these three objectives is not impossible. (Baker-IVI)
W84-02608

NONPOINT SOURCE WATER POLLUTION ABATEMENT AND THE FEASIBILITY OF VOLUNTARY PROGRAMS,

Wisconsin Univ.-Milwaukee. Dept. of Urban Planning.
D. S. Sawicki, and L. B. Judd.
Environmental Management, Vol. 7, No. 5, p 453-464, 2 Fig, 5 Tab, 13 Ref.

Descriptors: *Nonpoint pollution sources, *Water pollution control, *Voluntary programs, Decentralization, Institutional constraints, Urban areas, Rural areas, Root River watershed, Illinois.

A voluntary, decentralized institutional arrangement for nonpoint source water pollution control used in the Root River watershed in southeastern Wisconsin was studied in order to monitor and draw conclusions about the effectiveness of a voluntary, decentralized institutional system, to specify deficiencies of the approach and suggest means to correct them, and to use the conclusions to speculate about the need for regulations regarding nonpoint source pollution control or the appropriateness of financial incentives for nonpoint source control. This watershed was chosen because of its mix of urban, agricultural, and urbanizing land uses. Institutional factors considered include diversity of land uses in the watershed, educational needs, economic conditions, personality, water quality, number of agencies involved, definition of authority, and bureaucratic requirements. Fairly good progress was made toward securing cooperative agreements with landowners and committing cost share funds to implement rural nonpoint source control practices. There was little evidence that the institutional system used will result in implementation of urban runoff control practices. The decentralization used in the Root River watershed is responsible both for its degree of success and for many of the impediments to greater progress. The voluntary approach has been well received in the watershed and has been successful in committing cost-sharing money to soil-related (rural) practices. It has not resulted in committment to practices in the priority established in the plan and offers little control over the order in which practices are implemented. Decentralization does not offer as great an advantage for urban practices, and it may have hindered progress in the Root River watershed. (Moore-IVI)
W84-02643

PATTERNS IN GROUNDWATER QUALITY: SELECTED OBSERVATIONS IN IOWA,
Iowa Univ., Iowa City. Dept. of Geology.
R. Rajagopal, and R. L. Talcott.
Environmental Management, Vol. 7, No. 5, p 465-474, 1983. 6 Fig, 5 Tab, 18 Ref.

Descriptors: *Water quality, *Groundwater, *Iowa, Nitrates, Sulfates, Carbonates, Well water, Seasonal variation, Groundwater pollution, Runoff.

Groundwater quality in Iowa varies with depth, location, ownership of well, time of sampling, and geologic features. Samples from deep wells (>30.48 m or 100 ft) are highly mineralized with sulfates and carbonates (calcium and magnesium), whereas the mineral content in samples from shallow wells (<30.48 m or 100 ft) is relatively much lower. Nitrate as a percent of dissolved solids is negligible in samples from deep wells and reaches as high as 3 to 5% in samples from shallow wells. Shallow wells, in particular nonpublic wells, are highly susceptible to nitrate contamination (with an average concentration of 27.8 mg/l) compared with any other category of wells studied. In shallow non-public wells, the concentration of nitrate from recent geologic deposits (31.61 mg/l) is more than twice the level found in corresponding public wells from similar deposits (13.35 mg/l). Shallow non-public wells are also subject to sharp seasonal fluctuations, with a peak nitrate concentration of 55.81 mg/l in the month of May, possibly because of spring runoff from agricultural and other surface sources. These observations are further supported by the results of nitrate analyses from a large number (over 44,000) of private wells in Iowa. Eighteen percent of these private wells were found to exceed the maximum contaminant level of 45 mg/l nitrate, NO3(-). A higher proportion of the shallow wells (<30.48 m or 100 ft) exceed the maximum contaminant level of 45 mg/l (3867 out of 13,625 or 28.4%). It is proposed that the observed variability in groundwater quality be used as a first step in developing a strategy for strengthening state-wide groundwater quality monitoring programs. Strong state-wide programs would be of considerable assistance to policy makers in the resolution of major groundwater quality issues. (Author's abstract)
W84-02644

SECONDARY UTILIZATION OF TRACE ORGANICS BY BIOFILMS ON POROUS MEDIA,
California State Water Resources Control Board, Sacramento.
For primary bibliographic entry see Field 5D.
W84-02671

ACID RAIN DEBATE MAY PLAY A ROLE IN THE 1984 PRESIDENTIAL SWEEPSTAKES,
L. Mosher.
National Journal, Vol. 15, No. 20, p 998-999, May 14, 1983.

Descriptors: *Acid rain, *Legislation, Decision making, Planning, Management, Water quality control, Sulfur, Powerplants, Scrubbers.

A plan has been advanced to create an acid rain superfund by levying a tax of 0.3 cents per kilowatt hour on all users of electricity generated from fossil fuel-powered plants in 31 states that either border on or lie east of the Mississippi River. This fund would be used to help power plants pay for installing costly pollution control equipment such as scrubbers that remove sulfur from plant exhaust fumes. Other proposals for dealing with the acid rain problem are also briefly presented including the Mitchell-Stafford bills. Industry reaction to these various alternatives for dealing with the problem is outlined. (Baker-IVI)
W84-02696

BIOLOGICAL TECHNOLOGY OF THE TREATMENT OF LEACHATE FROM SANITARY LANDFILLS,
Australian Atomic Energy Commission, Sutherland. Lucas Heights Research Lab.
For primary bibliographic entry see Field 5D.
W84-02697

HYPOLIMNETIC AERATION AND DISSOLVED GAS CONCENTRATIONS; ENCLOSURE EXPERIMENTS,
York Univ., Downsview (Ontario). Dept. of Biology.
D. J. McQueen, and D. R. S. Lean.
Water Research, Vol. 17, No. 12, p 1781-1790, 1983. 10 Fig, 2 Tab, 48 Ref.

Descriptors: *Hypolimnion, *Aeration, *Dissolved gases, Mud-water interfaces, Nutrients, Dissolved oxygen, Methane, Hydrogen sulfide.

Two large circular enclosures, each containing approximately 550 cu m of water, 14 m deep, and open to the mud-water interface, were used to monitor the effects of hypolimnetic aeration. One enclosure was held as a control, the other aerated every 3 or 4 days for a period long enough (usually < 2h) to maintain hypolimnetic O2 levels at > 4 mg/l. Nutrient additions (10 g of 90% H3PO4 and 250 g NaNO3 per week) to each enclosure were controlled from the commencement of the experiment (17 June 1980) until its completion (2 November 1981). Temperatures in both enclosures were identical. Hypolimnetic O2 levels in the control fell to zero during both summers, but remained at >4 mg/l in the aerated enclosure. Free N2 concentrations in the hypolimnion of the aerated enclosure was higher than in the control. Concentrations of H2S in the control hypolimnion increased to >5 mg/l and concentrations of CH4 increased to > 18 mg/l. Both remained at or near zero in the aerated enclosure. Tests of aerator efficiency suggested that the full air-lift design that was employed had an average O2 exchange efficiency of 42% which is higher than the values reported for most other designs. (Author's abstract)
W84-02721

CONTROL OF DO LEVEL IN A RIVER UNDER UNCERTAINTY,
California Univ., Berkeley. Dept. of Biomedical and Environmental Health Sciences.
R. C. Spear, and G. M. Hornberger.
Water Resources Research, Vol. 19, No. 5, p 1266-1270, October, 1983. 1 Fig, 1 Tab, 16 Ref.

Descriptors: *Dissolved oxygen, *Mathematical models, *Water pollution control, Water quality, Simulation, Wastewater lagoons, Effluents, Rivers, Algae, Photosynthesis.

A regionalized sensitivity analysis for exposing critical uncertainties in models of environmental systems is extended to study control of systems for which there is a good deal of uncertainty in the mathematical model used to describe the appropriate physical, chemical, and biological processes. The method is based on a binary classification of Monte Carlo simulation results as being either satisfactory or unsatisfactory in terms of controller performance. Contrasts in parameters associated with the two classes are elucidated by statistical analysis. This allows the selection of a set of control parameters that maximizes the probability of acceptable behavior in the presence of uncertainty in process parameters. The method is applied to the problem of regulating the discharge from a lagoon with the object of preventing dissolved oyxgen (DO) from falling below a predetermined standard. Releases from the lagoon to the river are to be scheduled such that dissolved oxygen in the river is not driven below a specified water quality standard and such that the lagoon does not overflow nor fall below some minimum level. For this system the desired behavior of the controlled process can be achieved with a probability of 0.84 with a particularly simple controller design. If this probability were deemed insufficient, three courses of action are open: enlarge the lagoon, narrow the process parameter uncertainty, or investigate other controller structures. Two of the parameters associated with algal photosynthesis were critical to the controler's ability to maintain acceptable DO levels. Even modest levels of uncertainty in the process parameters can have a considerable effect on the controller performance and additional attention should be devoted to the design of robust controllers for environmental systems. (Moore-IVI)
W84-02767

EVALUATION OF SURFACE IMPOUNDMENT ASSESSMENT IN NEW MEXICO,
Geological Survey, Reston, VA.
M. Person, R. Antle, and D. B. Stephens.
Ground Water, Vol. 21, No. 6, p 679-688, November-December, 1983. 10 Fig, 2 Tab, 15 Ref.

Descriptors: *Groundwater pollution, *Surface impoundment assessment, *Waste disposal, Pits, Ponds, Groundwater management, Lagoons, Groundwater quality, Vadose water, Waste dumps, New Mexico.

Surface Impoundment Assessment (SIA) is a method for determining the potential for groundwater contamination from pits, ponds and lagoons. SIA produces a numerical rating of a site, based on the sum of scores assigned to four categories: vadose zone properties, groundwater availability, groundwater quality, and waste characteristics. The SIA for New Mexico was conducted as part of a nationwide survey of potentially hazardous waste disposal sites. The SIA showed a reasonably good agreement between predicted high potential for groundwater contamination and observed or suspected contamination. The Mann-Whitney U-Test and the stepwise logistic regression method for statistically evaluating the SIA results for New Mexico indicate that vadose zone characteristics and waste properties contribute most to the successful prediction of contamination through the use of the overall groundwater contamination potential score. Vadose zone properties comprise the only hydrogeologic characteristics considered in the SIA methodology to assess contamination potential. Hydrogeologic parameters included in the groundwater quality and groundwater availability steps in the SIA reflect the importance of the

aquifer as a water source, rather than its potential for contamination. One important consideration that was not included in the present study was the age of the impoundment. Many of the sites are less than 15 years old, so a number of the sites receiving a low or moderate contamination potential score may eventually become contaminated. Other factors such as rate of discharge into the impoundment and confidence in available data should be considered in predicting the contamination potential at surface impoundments. (Baker-IVI)
W84-02815

EVALUATING SYSTEM FOR GROUNDWATER CONTAMINATION HAZARDS DUE TO GAS-WELL DRILLING ON THE GLACIATED APPALACHIAN PLATEAU,
Allegheny Coll., Meadville, PA.
S. S. Harrison.
Ground Water, Vol. 21, No. 6, p 689-700, November-December, 1983. 12 Fig, 2 Tab, 2 Ref.

Descriptors: *Groundwater pollution, *Gas-well drilling, Appalachian Plateau, Pennsylvania, Glacial drift, Natural gas, Geohydrology, Groundwater movement, Geologic fractures, Permeability, Hydraulic gradient.

Limited, but increasing, groundwater contamination is occurring in the Glaciated Appalachian Plateau area of northwestern Pennsylvania due to recent drilling for natural gas in that area. The contamination hazard of a given site can be assessed through the evaluation of hydrogeologic parameters at the site including groundwater flow systems, permeability of surficial sediments, and the presence of fracture zones. Most hazardous sites appear to be located on or near valley walls of major drainageways. The relatively steep hydraulic gradient, the frequent presence of highly permeable surficial sediments, and the low to moderate dilution of contaminants along the intermediate length flow paths at these sites all contribute to a relatively high pollution hazard. In addition to locating gas wells in high hazard hydrogeologic zones, allowing the annulus of gas wells to become pressurized is the other major factor contributing to aquifer contamination. (Baker-IVI)
W84-02816

WATER QUALITY MANAGEMENT WITH TIME VARYING RIVER FLOW AND DISCHARGER CONTROL,
Louvain Univ. (Belgium). Centre for Operations Research and Econometrics.
J.-P. Herbay, and Y. Smeers.
Water Resources Research, Vol. 19, No. 6, p 1481-1487, December, 1983. 1 Fig, 4 Tab, 32 Ref.

Descriptors: *Water quality management, *River flow, *Wastewater treatment, Cost analysis, Water pollution sources, Mathematical models.

An extension of the classical river quality management problem is presented that allows for time varying operation of the treatment plants. The hydrology of the river is represented by a set of steady state flow regimes; a river water quality model is used for each of these regimes to give a constraint set to be imposed on the discharges in order to achieve the stream standards during that regime. The objective function distinguishes between investment costs, fixed operating costs, and variable operating costs. A treatment system is sought that minimizes the sum of these costs, taking account of the possibility of operating the treatment system at various different levels during the year. The model is quantified and tested on an example. (Author's abstract)
W84-02851

HEAT DISCHARGE REGULATIONS AND THE PROBLEM OF VARIABILITY OF NATURAL WATER TEMPERATURE,
Keuring van Electrotechnische Materialen N.V., Arnhem (Netherlands). Environmental Dept.
H. E. Sweers.
Water Science and Technology, Vol. 15, p 119-133, 1983. 11 Fig, 2 Tab, 11 Ref.

Descriptors: *Heated water, *Regulations, *Natural waters, *Water temperature, International agreements, Thermal pollution, Thermal stratification.

Cooling water regulations are designed to minimize possible harmful effects of cooling water discharges on the aquatic environment. The philosphy behind the various regulations is not always the same. Regulations can set design requirements for cooling water systems in such a manner that harmful conditions can not develop in the environment during normal operation of the system. On the other hand, regulations can be drafted with the sole purpose to limit the values of certain parameters in the environment while the system is in operation. An overview is given of the regulations for cooling water discharges in force in some European countries. There are certain problems that arise from the adherence to the regulations especially problems arising from the horizontal variability of the water temperature. The horizontal variability may be quite large even in seemingly homogeneous water bodies. Even when the monthly or yearly mean temperatures are almost equal, instantaneous temperature differences up to 2-4 K may occur at locations only a few kilometers apart. (Murphy-IVI)
W84-02939

6. WATER RESOURCES PLANNING

6A. Techniques Of Planning

MANAGEMENT TRAINING AS A TROUBLESHOOTING TOOL,
Metcalf and Eddy, Inc., Boston, MA.
W. Peterson, and G. Manolakis.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1051-1056, August, 1983.

Descriptors: *Management planning, *Training, *Wastewater treatment facilities, Troubleshooting, Education, Planning, Costs.

Key elements of an effective management training program include: thorough evaluation/needs assessment by experienced personnel; frank communications with the political/administrative leaders and subsequent committment by those leaders to address problems; initials awareness training aimed at supervisors and focusing on leadership, communications problem solving, and human relations; parallel interactions with technical troubleshooting; and follow-up coaching to assist the supervisor in the work place. Management training should be a critical part of startup training programs for new facilities, should be part of every plant's ongoing training program, and is critical to troubleshooting success. The management training program represents a small fraction of the total troubleshooting or start-up effort in every instance, but its impact on the outcome in either case is substantial. Management training is highly cost effective. (Baker-IVI)
W84-02572

SURVIVING THE JOHNSTOWN, PA., FLOOD,
Laurel Management Co., Johnstown, PA.
For primary bibliographic entry see Field 4A.
W84-02667

MULTIPLE RESERVOIR SYSTEM SCREENING MODELS,
Cornell Univ., Ithaca, NY. Dept. of Environmental Engineering.
J. R. Stedinger, B. F. Sule, and D. Pei.
Water Resources Research, Vol. 19, No. 6, p 1383-1393, December, 1983. 3 Fig, 4 Tab, 41 Ref. OWRT project B-094-NY, grant 14-34-0001-1250.

Descriptors: *Reservoirs, *Model studies, Decision making, Planning, Multireservoir networks, Reservoir releases.

A deterministic reservoir screening model based upon the historical mean monthly flows did not provide sufficient reservoir capacity to achieve reasonable system reliabilities for the design of a large multiple-reservoir system. Three models that explicitly describe the anticipated reliability of multiple reservoir system releases were considered. Of the linear decision rule (LDR) chance-constrained models, those using the S type release rule structure substantially overestimated reservoir capacity requirements. The designs obtained with LDR models that use the SQ type release rule structure were more reasonable but still were not always satisfactory. The recently developed yield model consistently produced reasonable reservoir system designs with release reliabilities near the target. The operating policies produced by the LDR screening models, when stimulated, failed to utilize available water and storage space efficiently, given the objectives of the assignment. For a multiple reservoir system with three reservoirs in parallel, more efficient operating policies were obtained by using Bower's space rule. These results are consistent with those presented by Stedinger for single reservoir operation. (Baker-IVI)
W84-02841

CONSERVATIVE ESTIMATION OF GROUNDWATER VOLUMES: APPLICATION OF LINEAR PROGRAMMING TO TRITIUM DATA,
Waikato Univ., Hamilton (New Zealand). Dept. of Earth Sciences.
For primary bibliographic entry see Field 4B.
W84-02893

6B. Evaluation Process

A MANAGEMENT APPROACH TO ENERGY COST CONTROL IN WASTEWATER UTILITIES,
Peat, Marwick, Mitchell and Co., Washington, DC.
W. M. Prindle, D. A. Buell, and L. J. Scully.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1239-1243, October, 1983. 7 Fig, 1 Tab.

Descriptors: *Decision making, *Wastewater treatment, *Economic aspects, Planning, Management, Energy, Cost analysis.

Cost-effectiveness energy management in wastewater treatment plants should consider specific cost elements of energy use in the plant as a whole and in individual process units. Energy efficiency measures, to achieve maximum cost savings, must be designed to address the specific features of the plant's electricity costs. A time-based cost profile must be developed to accurately evaluate conservation options. To the extent that demand changes and time of day or seasonal features are built into the electric costs, the strategy should include the development of detailed load data on major treatment units, and use to maintain accurate time-based cost profiles; consideration of added instrumentation to afford data and control capabilities needed for effective load management; evaluation of modest load deferral options such as rescheduling some solids processing to off-peak hours on a daily basis; exploration of methods to control monthly and annual peaks, such as using wet wells to their maximum capability, flow equalization ponds, reduction of storm related combined sewer flow, and reduction of infiltration and inflow; and consideration of use of internal electric generation for peak load reduction. (Baker-IVI)
W84-02592

LEAST COST PROCESS DESIGN FOR GRANULAR ACTIVATED CARBON ADSORBERS,
Zenon Environmental, Inc., Burlington (Ontario).
R. M. Narbaitz, and A. Benedek.
Journal of the Water Pollution Control Federation, Vol. 55, No. 10, p 1244-1251, October, 1983. 12 Fig, 2 Tab, 5 Ref.

Descriptors: *Cost analysis, *Activated carbon, *Adsorbers, Wastewater treatment, Adsorbents, Adsorption, Design criteria, Planning, Manage-

ment, Decision making, Economic aspects, Model studies, Computers.

A newly developed design package, called MASTOR, incorporates a recent breakthrough in the understanding of the adsorption process. This package simulates the column's performance and can determine the carbon usage and the cost of constructing and operating different types of column arrangements, thereby providing the possibility of finding the least cost design. MASTOR stands for McMaster Adsorption Systems Optimization Routines and consists of a set of computer programs that models and estimates the costs of four different types of column configurations: single column systems, series systems, parallel systems, and parallel-series systems. (Baker-IVI)
W84-02593

PLANNING FOR ALKALI LAND RECLAMATION UNDER RAINFALL UNCERTAINTY,
Central Soil Salinity Research Inst., Karnal (India). Div. of Agricultural Engineering.
N. K. Tyagi, and V. V. D. Narayana.
Ecological Modelling, Vol. 20, No. 4, p 243-258, December, 1983. 5 Fig, 6 Tab, 12 Ref.

Descriptors: *Land reclamation, *Rainfall, *Alkaline soils, *Planning, *Water use, Model studies, Stochastic process, Land use, Haryana Canal, India.

For the reclamation and utilization of alkali soils, which are characterized by high pH, high exchangeable sodium percentage, and low infiltration rate, for crop production, there is a highly water-dependent technology. A chance-constrained linear programming model with rainfall as stochastic input was developed to plan optimal land and water use in alkali soils under reclamation. The model is based on the water balance of a typical alkali catchment in the command area of the Western Jamuna Canal in Haryana (India). The zero-order decision rule has been used to obtain the deterministic equivalent of chance constraint and optimal solutions have been obtained for four levels of rainfall probability. The application of the model to a typical alkali area of the Indo-Gangetic plains indicates that great risks are taken if reclamation programs are undertaken on the basis of mean rainfall data. For sustained higher-cost alkali land reclamation technology, it is essential that the stochastic nature of the rainfall input is taken into consideration and that land and water use plans are developed at a higher degree of security. (Moore-IVI)
W84-02837

IMPROVED RISK AND RELIABILITY MODEL FOR HYDRAULIC STRUCTURES,
Texas Univ. at Austin. Dept. of Civil Engineering.
For primary bibliographic entry see Field 8A.
W84-02845

A METHODOLOGY FOR EVALUATION OF FLOOD FORECAST-RESPONSE SYSTEMS; 1. ANALYSES AND CONCEPTS,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
R. Krzysztofowicz, and D. R. Davis.
Water Resources Research, Vol. 19, No. 6, p 1423-1429, December, 1983. 3 Fig, 43 Ref. NWS contract 6-35229, NSF grant CEE-8107204.

Descriptors: *Flood forecasting, *Economic evaluation, *Mathematical models, Warning systems, Decision making, Flood damage, Economic aspects, Flood protection.

Determination of the value of flood forecasts at a microeconomic level necessitates the consideration of numerous hydrologic, organizational, behavioral, and economic factors. These factors and their interactions are captured in a concept of a flood forecast-response (FFR) system. The forecast system extends from the collection of data through the forecasting of floods to the dissemination of warnings. The response system encompasses decision making by the floodplain dweller (decision maker, DM) and the protective actions taken. A methodology is presented which concerns specifically the economic evaluation of the effectiveness of riverine flood forecasts as a means of reducing property damage. The methodology is built of a model of the FFR process and a performance theory. The first element provides a comprehensive mathematical description of the physical FFR process which takes place during floodings; it outputs the expected annual losses (cost of protective action plus flood damage) incurred by the floodplain dweller under several scenarios. The second element establishes the performance measures and expresses them in terms of the outputs of the FFR model; the measures consist of values (expected annual reductions of the loss), efficiencies, and expected opportunity losses. The performance theory has three attractive features. First, the sufficient statistic of system performance consists of only four numbers; thus the computational effort required to evaluate a sysem is relatively small. Second, the evaluations of FFR(DM) systems can be aggregated to obtain an evaluation of the FFR(reach) system. Third, in each case, a display of at most nine numbers (three values, three efficiencies, three expected opportunity losses) provides a comprehensive picture of the system. The values constitute the benefit entry to the benefit-cost or cost-effectiveness analysis. The efficiencies provide a means of comparing the performance of system components. The expected opportunity losses define the upper bounds on the values of different system improvements. (Moore-IVI)
W84-02846

A METHODOLOGY FOR EVALUATION OF FLOOD FORECAST-RESPONSE SYSTEMS; 2. THEORY,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
R. Krzysztofowicz, and D. R. Davis.
Water Resources Research, Vol. 19, No. 6, p 1431-1440, December, 1983. 5 Fig, 3 Tab, 5 Ref. NWS contract 6-35229, NSF grant CEE-8107204.

Descriptors: *Flood forecasting, *Economic evaluation, *Flood damage, Economic aspects, Markov chain, Decision making, Mathematical models.

A methodology for evaluation of the performance of flood forecast-response (FFR) systems is presented. It is built of (1) a model of the FFR process and (2) a set of performance measures. The FFR process is formulated as a finite, random duration, Markovian decision process which outputs the expected annual loss (cost of response plus flood damage sustained). The sequence of forecasts of the flood crest and the actual river stages are described by a two-branch Markov chain of order one. The decision maker's response is represented by a strategy defined on a three-dimensional state vector and time. The performance measures consist of a value, an efficiency, and an expected opportunity loss for each system component as well as the total system. They are defined on a vector of outputs, each output being computed for a distinct scenario of system operation. Two evaluation models are constructed: one for a single decision maker and another for an arbitrary collection of decision makers along a reach (e.g., a community). (Author's abstract)
W84-02847

A METHODOLOGY FOR EVALUATION OF FLOOD FORECAST-RESPONSE SYSTEMS; 3. CASE STUDIES,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
R. Krzysztofowicz, and D. R. Davis.
Water Resources Research, Vol. 19, No. 6, p 1441-1454, December, 1983. 18 Fig, 11 Tab, 14 Ref. NWS contract 6-35229, NSF grant CEE-8107204.

Descriptors: *Flood forecasting, *Economic evaluation, *Flood damage, Decision making, Mathematical models, Economic aspects, Flood protection, Pennsylvania, Milton, Texas, Victoria, Mississippi, Columbus.

Case studies are reported to illustrate a methodology for evaluation of the performance of flood forecast-response (FFR) systems. The methodology concerns specifically the economic evaluation of the effectiveness of riverine flood forecasts as a means of reducing property damage. The case studies include the evaluation of the FFR systems in three communities: Milton, Pennsylvania; Victoria, Texas; and Columbus, Mississippi. The first study is reported in greater detail, and then a comparative analysis of all three systems is presented. An example is given of evaluation of the economic worth of flood forecasts from the viewpoint of an individual decision maker. The methodology can serve as a decision aid to an individual decision maker who wants to make optimal use of flood forecasts, an evaluation tool for a river forecast service which is concerned with the design and operation of flood forecast systems, a planning aid to urban planners and decision makers who are concerned with floodplain management and disaster-preparedness programs for communities. Evaluation of he performance of an FFR system requires knowledge of human response behavior. The economic value of an FFR system is very sensitive to the strategy the decision maker employs in response to the flood forecasts. Nonoptimal response strategy does not allow the full potential of the forecast system to be realized. If, as a result of the limited lead time of the forecasts, the decision constraint is binding, then the optimal strategy is anticipatory. Since commercial and industrial establishments are often located low in the floodplain, and since their managers have the capability of understanding, developing, and using sophisticated response strategies, it appears that user-tailored flood forecasts have a large potential for extending the economic benefits of weather information. (Moore-IVI)
W84-02848

CATEGORY-UNIT LOSS FUNCTIONS FOR FLOOD FORECAST-RESPONSE SYSTEM EVALUATION,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
R. Krzysztofowicz, and D. R. Davis.
Water Resources Research, Vol. 19, No. 6, p 1476-1480, December, 1983. 9 Fig, 1 Tab, 16 Ref. NWS contract 6-35229, NSF grant CEE-8107204.

Descriptors: *Flood damage, *Flood forecasting, *Economic evaluation, Warning systems, Decision making.

Economic evaluation of the performance of a flood forecast-response system requires a large amount of information for the estimation of a loss function. This function must encode the cost of protective action undertaken in response to flood warnings and the flood damage sustained. The concept of category-unit functions is exploited to reduce field survey demands and to circumvent high computation requirements. The loss function consists of a unit damage function, a unit cost function, and a unit reduction function; the degree of response that can be actually implemented is bounded by a decision constraint function. These four functions are estimated from data of various origins for seven categories of structures and three categories of decision makers. (Author's abstract)
W84-02850

6C. Cost Allocation, Cost Sharing, Pricing/Repayment

COST OF CLEAN WATER--IMPACT ON SMALL COMMUNITIES,
McNamee, Porter and Seeley, Ann Arbor, MI.
For primary bibliographic entry see Field 5D.
W84-02565

THE EFFECTS OF A CHANGE IN THE VARIABILITY OF IRRIGATION WATER,
Utah State Univ., Logan. Dept. of Economics.
K. S. Lyon.
Water Resources Research, Vol. 19, No. 5, p 1122-1126, October, 1983. 3 Tab, 4 Ref.

Descriptors: *Irrigation water, *Economic impact, *Variability, Economic aspects, Profit, Stochastic process, Water resources development.

This paper examines the short-run effects upon several variables of an increase in the variability of an input. The measure of an increase in the variability is the 'mean preserving spread' suggested by Rothschild and Stiglitz (J. Econ. Theory, 2,225-243, 1970). The variables examined are real income (utility), expected profits, expected output, the quantity used of the controllable input, and the shadow price of the stochastic input. Four striking features of the results follow: (1) the concepts that have been useful in summarizing deterministic comparative static results are nearly absent when an input is stochastic; (2) most of the signs of the partial derivatives depend upon more than concavity of the utility and production functions; (3) if the utility function is not 'too' risk averse, then the risk-neutral results hold for the risk-aversion case; (4) if the production function is Cobb-Douglas, then definite results are achieved if the utility function is linear or if the 'degree of risk-aversion' is 'small.' (Author's abstract)
W84-02758

MARKET SIMULATIONS FOR IRRIGATION WATER RIGHTS: A HYPOTHETICAL CASE STUDY,
Illinois Univ. at Urbana-Champaign. Dept. of Civil Engineering.
B. D. C. Wong, and J. W. Eheart.
Water Resources Research, Vol. 19, No. 5, p 1127-1138, October, 1983. 9 Fig, 1 Tab, 14 Ref.

Descriptors: *Water rights, *Irrigation water, *Simulation, *Water rights markets, Permits, Water use, Water allocation, Economic aspects.

The efficiency of two marketable water rights systems in a lentic (lakelike) structure is assessed quantitatively for a case study based on hypothetical irrigation water use. Water rights are simulated on the bases of (1) the expected values of water rights to the users and (2) perfect foresight on the parts of users, and the economic outcomes of these markets are evaluated from both ex ante and ex post perspectives. The market outcomes are compared to the optimal (efficient) scheme and to two alternative nonmarket policies. Distributional aspects of the markets are examined on the basis of individual payoff. Simulation results show that higher efficiency is obtained for the two market systems than for the nonmarket policies and that the market systems recoup about 95% of the economic value of the optimal distribution. The results suggest that most of the 5% efficiency loss should be attributed to the design of the market system itself (i.e., the restrictions imposed by the definition of the rights and/or the water rights allocation policy), rather than the users' inability to predict future events. (Author's abstract)
W84-02759

THE ECONOMICS OF IRRIGATION WITH NONUNIFORM INFILTRATION,
California Univ., Riverside. Dept. of Soil and Environmental Sciences.
For primary bibliographic entry see Field 4A.
W84-02844

6D. Water Demand

USE OF SURFACE WATER FOR REARING CHANNEL CATFISH IN PONDS,
Fish Farming Experimental Station, Stuttgart, AR.
D. L. Tackett, and R. R. Carter.
Progressive Fish-Culturist, Vol. 45, No. 3, p 179-180, July, 1983. 2 Tab, 2 Ref.

Descriptors: *Fish farming, *Water quality, *Catfish, Turbidity, Surface water, Filtration, Water treatment, Coagulation, Ponds, Turbidity, Aquatic plants, Arkansas.

The level of the water table is dropping as much as 30 cm in some areas of Arkansas each year, of which about 8% is a result of fish farming. While more surface water should be developed for fish farming, exposure to sources of pollution is a problem. The use of filtration or treatment with 20 mg/L coagulant were tried to improve the quality of the surface water for fish production. Surface water characteristics varied over a wide range due to irregular streamflow, rainfall, land use in the drainage area, and other factors. Treatment of raw water with coagulant significantly reduced turbidity on three of the four test dates, but had no effect on biochemical oxygen demand, pH, alkalinity, carbon dioxide, or hardness. Surface waters containing clay turbidity had no detrimental effect on fish husbandry. The type of water supplied (raw, treated, or filtered) did not affect fish production. Some turbidity may be desirable as clear water ponds may develop dense aquatic vegetation making them difficult or impossible to seine. In 1980, emergent and submerged vegetation did develop in ponds containing raw water treated with coagulant at 20 mg/L. Three of the six ponds with treated water were difficult to seine and the other three could not be seined. Vegetation posed a seining problem in only one of the six raw water ponds. In 1981, when less coagulant was used and water was more turbid in all ponds, all 16 ponds could be seined without difficulty. (Baker-IVI)
W84-02510

RURAL WASTEWATER PLANNING,
New York State Dept. of Environmental Conservation, Albany.
M. M. Wolfson.
Journal of the Water Pollution Control Federation, Vol. 55, No. 8, p 1042-1050, August, 1983. 1 Fig, 1 Tab, 9 Ref.

Descriptors: *Planning, *Wastewater facilities, *Rural areas, Grants, Wastewater disposal, Small communities, Domestic wastes, Wilmington, New York.

The town of Wilmington, New York was selected by the NYSDEC as a pilot project to determine how a small community could use the EPA Construction Grants Program to solve its wastewater disposal problems. The study suggests that new planning approaches are needed because the current program does not incorporate a suitable procedure for solving wastewater disposal problems in small communities. The community of Wilmington is very rural in nature, characterized by steep rugged terrain typical of the high peaks region of the Adirondack Mountains. Very high ground water and hillside springs can be found in the more remote and mountainous areas. All wastewater is disposed of by on-site systems because there are no central collection and treatment facilities. Many of the on-site systems have failed. The most densely settled portion of the town is served by a municipal water system; the remaining residents rely on private wells for their water supply. In many areas it appears that groundwater is being impaired because of the discharge of improperly treated wastewater. A HUD Community Development Block Grant for improving properties of low-income families allowed the replacement or repair of some 60 malfunctioning on-site wastewater disposal systems. A NYSDEC Survey was conducted covering 181 wastewater generating facilities, both private and commercial. The survey indicated that more resources should be devoted to the regulation of on-site systems, that public management of on-site systems is necessary to supplement existing regulatory controls, public education is an absolute necessity in improving rural wastewater disposal, facilities planning conducted under the EPA Construction Grants Program must be streamlined, that small community officials must accept responsibility to protect public health, that regulatory personnel and project sponsors should be fully aware of the effect that local politics can have on planning proposal, and that the concept of a wastewater disposal district represents a relatively new and untried option for small communities and is often impacted by complex legal issues. (Baker-IVI)
W84-02571

ESTIMATING THE EFFECT OF WATER QUALITY ON SURFACE WATER SUPPLIES,
Anglian Water Authority, Huntingdon (England). Dept. of Operational Planning.
A. E. Warn, and C. Page.
Water Research, Vol. 18, No. 2, p 167-172, 1983. 3 Fig, 1 Tab, 15 Ref.

Descriptors: *Water quality, *Regression analysis, *Water supply, River flow, History, Mathematical models, Water quality control, Simulation, Nitrates, Reservoir operation, Pumped storage, Water pollution control.

Records of river water quality provide information on the suitability of rivers for various uses. In assessing the future of water supplies, these records must be supplemented with information about the effects of effluent discharges, abstractions, changing patterns of land use and hydrological conditions not encountered in the period covered by the record. A method of accounting for these effects uses multiple regression analysis to produce long sequences of river quality data, which are compatible with historical records of river flow. The method has been applied to predict levels of nitrate, sulfate, and chloride in rivers and pumped storage reservoirs. It enables a proper evaluation of the methods of controlling the quality of water put into public supply. Results for nitrate show that to operate intakes according to river quality is a poor method of controlling quality in impoundments. (Moore-IVI)
W84-02746

CONJUNCTIVE USE OF GROUNDWATER AND SURFACE WATER FOR IRRIGATED AGRICULTURE: RISK AVERSION,
Geological Survey, Menlo Park, CA. Water Resources Div.
For primary bibliographic entry see Field 4B.
W84-02756

DETERMINANTS OF FARM WATER SUPPLY IN THE LOWER BHAVANI PROJECT, COIMBATORE, SOUTH INDIA,
Minnesota Univ., Minneapolis. Dept. of Agriculture and Applied Economics.
K. Palanisami, and S. R. Subramanian.
Water Resources Research, Vol. 19, No. 6, p 1403-1409, December, 1983. 3 Fig, 6 Tab, 12 Ref.

Descriptors: *Water supply, *Irrigation canals, *India, *Coimbatore, *Lower Bhavani Project, Social aspects, Conjunctive use, Water stress, Paddy crops, Water allocation, Water management.

In India, systems of canal irrigation have been designed and operated with the objective of maximizing the number of irrigation beneficiaries. They are aimed at providing water to the maximum area possible, and thus the principles of providing the optimum water to the crops and equity in the distribution of water to all the beneficiaries of the canal system have not been given due recognition. A study was conducted in the Lower Bhavani Project (LBP) Area in Coimbatore District, Tamil Nadu during 1978-1979 with the objective of identifying the determinants of farm water supply. The distance of a farmer's field from the outlet of the supply channel, size of the farm, number of intervening farmers, social characteristics, and possession of wells for supplementing the canal water were the key variables determining the canal water supply at the farm level. Direct distance and lateral distances of the supply channel in the head and middle portions and direct, lateral, and sublateral distances in the tail portion markedly influenced the stress days and yield of paddy crops. The buildup of stress days was higher at the direct distance category. Under the current method of allocating water to only half of the command area in each year and with the consequent water distribution problems, changes in the system of water distribution below the outlet would have more significant impacts on farm level water supply in the Lower Bhavani Project than changes above the outlet. Changes in water allowance concept, introduction of on-farm development activities, conjunctive use of surface and groundwater, and introduction of changes in the main system man-

agement were suggested for improving the performance of the system as a whole. (Moore-IVI)
W84-02843

TIME PATTERNS OF WATER USE IN SIX TEXAS CITIES,
Texas Univ. at Austin. Dept. of Civil Engineering.
D. R. Maidment, and E. Parzen.
Journal of Water Resources Planning and Mangement, Vol. 110, No. 1, p 90-106, January, 1984. 5 Fig, 6 Tab, 17 Ref.

Descriptors: *Time series analysis, *Water use, *Texas, Consumptive use, Prediction, Andrews, Canyon, Littlefield, Conroe Henderson, Huntsville.

The time variation of data from 6 Texas cities may be divided into long memory (on average, 70% of total variation), short memory (15%) and residual error (15%). Long-memory results from trend and seasonal variation. In each city, trend is analyzed by stepwise regression of mean annual water use on population, number of water connections, household income and water prices, in which population is consistently the most significant explanatory variable for trends in water use from year to year. Short-term memory results from autocorrelation and climatic correlation. Climate correlation is strong in the three cities in the semiarid High Plains of Texas where if one inch more than mean monthly rainfall or pan evaporation occurs, it results on average in a 10 gpcd (38 Lpcd) change in mean monthly water use (decrease for rainfall, increase for evaporation). In three cities in humid East Texas the response of water use to weather variations is weaker. Confidence limits on modeled water use adequately envelop the response of water use to the droughts experienced by these cities from 1961-1978. (Murphy-IVI)
W84-02922

6E. Water Law and Institutions

AN ANALYSIS OF REGULATIONS: THEIR IMPACT ON EFFLUENT MANAGEMENT THROUGH PROCESS CONTROL,
National Council of the Paper Industry for Air and Stream Improvement Inc., New York.
W. J. Gillespie, and R. O. Blosser.
Tappi Journal, Vol. 66, No. 12, p 34-36, December, 1983. 3 Ref.

Descriptors: *Decision making, *Regulations, *Effluents, Wastewater disposal, Pulp and paper mills, Pulp and paper industry, Industrial wastes.

The current structure of regulations governing effluent discharges are examined along with anticipated trends in the development of these regulations. Included are those aspect of the regulations that may influence the development of an individual pulp and paper mill's control strategy. Examples are given to illustrate the tools available to mill management for making decisions as to the most cost-effective approach in a given situation. The overall structure and operation of the Effluent Guidelines and the NPDES permit program do not offer any particular incentive for mills to achieve discharge limitations via internal process control rather than external treatment technologies. However, there are some detailed aspects of the program which may provide limited incentives toward the internal control approach. Persons responsible for mill compliance programs are urged to undertake a careful study of the emerging regulations and to maintain a close working relationship with EPA and state agency officials. (Baker-IVI)
W84-02913

HEAT DISCHARGE REGULATIONS AND THE PROBLEM OF VARIABILITY OF NATURAL WATER TEMPERATURE,
Keuring van Electrotechnische Materialen N.V., Arnhem (Netherlands). Environmental Dept.
For primary bibliographic entry see Field 5G.
W84-02939

6F. Nonstructural Alternatives

WATERSHED LAND-USE PLANNING UNDER UNCERTAINTY,
Manitoba Univ., Winnipeg. Dept. of Civil Engineering.
I. C. Goulter, H. G. Wenzel, Jr., and L. D. Hopkins.
Environment and Planning A, Vol. 15, No. 7, p 987-992, July, 1983. 15 Ref.

Descriptors: *Land use, *Flood plain management, *Planning, *Model studies, Uncertainty, Decision making, Watersheds, Regulations.

The pattern of land use can affect flood damage either by eliminating from the floodplain those land uses that are susceptible to flood damage or by reducing the increase in flood peaks that occurs as a consequence of development. A model of watershed land-use planning is formulated that improves on existing models by recognizing that land-use decisions have uncertain outcomes and that land uses change over time. Although land uses may be selected as the intended outcome of decisions or regulations, there is no certainty that these intended land uses will occur or that they will remain throughout the period of interest. Although a heuristic solution approach has been proposed, it is doubtful whether the effort to gather the required information would be justified in applying the model to a real watershed problem. The model is important, however, becauses it formalizes a more realistic concept of the problem of choosing land-use decisions to aid in achieving flood management objectives. (Moore-IVI)
W84-02639

CONTRACTUAL REQUIREMENTS TO IMPLEMENT WATER RECLAMATION,
Montgomery (James M.), Inc., Pasadena, CA.
R. L. Anderton, and N. G. Hixson.
Industrial Water Engineering, Vol. 20, No. 3, p 13-20, 1983.

Descriptors: *Legal aspects, *Water reuse, *Reclaimed water, Pulp and paper industry, Electroplating industry, Industrial wastes, Textiles, Contracts, Recreational facilities.

Major contractual considerations in developing water reuse projects are quality, quantity, price and health concerns due to the type of water supplied. These questions are addressed in this major reuse market survey which dealt with pricing, health concerns, industrial applications, specifics for the textile and paper industries as well as electroplating and glass container manufacturing industries. Oil well injection for repressurization and landscape irrigation uses of reclaimed water are touched upon. A sample reuse contract between a reclaimed water supplier, a retail water municipal surveyor, and a private country club for the purpose of providing reclaimed water in lieu of fresh water for golf course and landscape irrigation is offered. The draft document is not a legal contract, but is intended to illustrate the basic points that should be considered in a three party reuse contract. (Baker-IVI)
W84-02666

ANALYZING ALTERNATIVE FLOOD DAMAGE REDUCTION MEASURES ON SMALL RURAL WATERSHEDS USING MULTIPLE RETURN PERIOD FLOODS,
Manitoba Univ., Winnipeg. Dept. of Civil Engineering.
I. C. Goulter, and D. R. Morgan.
Water Resources Research, Vol. 19, No. 6, p 1376-1382, December, 1983. 5 Fig, 3 Tab, 10 Ref.

Descriptors: *Flood control, *Nonstructural alternatives, *Agricultural watersheds, Economic feasibility, Flood damage, Crops, Flood-control storage, Manitoba, Wilson Creek Watershed.

In many areas of rural Manitoba, conventional flood control measures such as diking and channel clearing are proving to be ineffective, both in their cost and in their ability to reduce flood damages. A heuristic techniques has been developed to assess the economic feasibility of a number of unconventional measures for flood damage reduction. Two measures considered are: (1) substitution of crops with a low susceptibility to flood damage for crops with a high susceptibility to flood damage and (2) storage of floodwaters on poor crop land to prevent flood damage on better crop land downstream. The probability of occurrence of various flood events is incorporated into the technique. The method is based upon the dynamic programming optimization technique and has been developed with particular emphasis on the Wilson Creek Watershed on the eastern boundary of Riding Mountain National Park, Manitoba, Canada. (Author's abstract)
W84-02840

6G. Ecologic Impact Of Water Development

EFFECTS OF COMPLETE REDD DEWATERING ON SALMONID EGG-HATCHING SUCCESS AND DEVELOPMENT OF JUVENILES,
Idaho Cooperative Fishery Research Unit, Moscow.
D. W. Reiser, and R. G. White.
Transactions of the American Fisheries Society, Vol. 112, No. 4, p 532-540, July, 1983. 1 Fig, 4 Tab, 18 Ref.

Descriptors: *Salmon, *Redds, *Hatching, *Drying, *Streamflow depletion, Larvae, Temperature, Sediments.

The effects of prolonged stream desiccation on development of salmonid eggs were simulated for steelhead Salmo gairdneri and spring chinook salmon Onchohynchus tshawytscha. Recently fertilized eggs were placed in artifical redds and subjected to controlled water flows in outdoor laboratory channels. Control redds were continuously submerged. 'Dewatered' redds were exposed to air; water flowed through the substrate 10 cm below the eggs. Eggs were dewatered 1-4 weeks (steelhead) or 1-5 weeks (chinook salmon) before they were returned to water in hatchery incubators, where hatching success and subsequent fry development were monitored. Several combinations of cobble, coarse sediment, and fine sediment used to cover eggs did not influence egg development, provided the mixtures retained at least 4% moisture by weight. Dewatered eggs hatched sooner than control eggs; faster hatch was associated with higher substrate temperature in exposed redds. Hatching success of dewatered eggs averaged 94% for steelhead (control: 88%) and 76% for chinook salmon (control: 56%) and was not affected by the time eggs had been dewatered. After 8 (chinook salmon) and 8.5 (steelhead) weeks of rearing, juveniles from dewatered and control eggs had grown equally well. (Author's abstract)
W84-02528

CHARACTERIZATION OF TRACE AND TOXIC MATERIALS IN SEDIMENTS OF A LAKE BEING RESTORED,
Louisiana State Univ., Baton Rouge. Center for Wetland Resources.
R. P. Gambrell, C. N. Reddy, and R. A. Khalid.
Journal of the Water Pollution Control Federation, Vol. 55, No. 9, p 1201-1210, September, 1983. 1 Fig, 6 Tab, 15 Ref.

Descriptors: *Lake restoration, *Lake sediments, *Dredging, *Land disposal, Productive use, Cadmium, Lead, Zinc, City Park Lake, Baton Rouge, Louisianna, Infiltration, Soil properties, Lime, Sediments, Spoil banks, Water pollution control.

Sediment materials were characterized and the levels of nutrients and toxic materials present were determined form materials gathered from nine sampling sites on City Park Lake, Baton Rouge, LA. The samples were taken to determine the effectiveness of using upland disposal/productive-use alternatives as possible environmentally acceptable methods of placing dredged sediments as opposed to the open-water disposal of dredged sediments

taken during restoration work on lakes. The initial chemical characterization study of City Park Lake indicated lead, zinc, and cadmium levels as areas for concern. Liming to increase dredged material pH should effectively reduce the plant availability of these metals so that plant growth will not be adversely affected, and animal and human health also will not be jeopardized by consumption of these plants. To give faster settling of solids and speed dewatering at the disposal site, lime would probably be introduced to the dredged slurry if hydraulic dredging is used to enhance flocculation of colloidal clay and organics. This will tend to reduce the dissolved levels of the three metals as well. The extent of dilution with surface water at the disposal site, as well as the duration of the dewatering operation also must be determined to evaluate the environmental significance of lead, zinc, and cadmium in the water draining from an upland disposal site. With proper management to minimize adverse effects of potentially toxic materials, the nitrogen, phosphorus, and trace nutrient metal content of the sediments will probably enhance crop production. (Baker-IVI)
W84-02591

CAN TVA CHANGE ITS SPOTS,
F. Powledge.
Audubon, Vol. 85, No. 2, p 60-75, March, 1983. 15 Fig.

Descriptors: *Water quality control, *Water pollution control, Tennessee, Tennessee Valley Authority, Powerplants, Dams, Planning, Management, Conservation, Environmental effects.

Over the years since its beginning the Tennessee Valley Authority became a producer of cheap power, with little concern for the simultaneous production of air, water, and land pollution. While the agency has always maintained staffs and facilities for studying and demonstrating ways to conserve and restore the region's natural resources, far more emphasis was placed on the aspects of power generation, heavy construction, dam building, and river harnessing. Nine major dams were built and 42 more were placed on tributaries. A 650-mile long navigable waterway was carved into the river, up from its junction with the Ohio at Paducah, Kentucky. With the dams came 49 hydroelectric powerplants. In the late 1970s a change in leadership came to the TVA. The change brought with it an increasing concern about the relationship of the TVA to environmental control. TVA's newly articulated mission is being furthered on a number of fronts, from experiments with growing catfish in leftover heated water from a steam plant to research into new forms of fertilizers. Programs of special interest to the environment are those involving the stewardship of the valley's water, air, and land, and those that encourage conservation and reuse of its renewable resources. A clear demonstration of TVA's change of heart may be found in its attitude toward energy conservation and the use of renewable energy sources such as the light and heat from the sun. (Baker-IVI)
W84-02618

VALUATION OF THE ENVIRONMENTAL IMPACT OF WETLAND FLOOD PROTECTION AND DRAINAGE SCHEMES,
University of East Anglia, Norwich (England). School of Environmental Sciences.
R. K. Turner, D. Dent, and R. D. Hey.
Environment and Planning A, Vol. 15, No. 7, p 871-888, July, 1983. 3 Fig, 7 Tab, 39 Ref.

Descriptors: *Environmental effects, *Wetlands, *Drainage, *Flood control, *Cost-benefit analysis, Economic aspects, Farming, Land development, Yare Barrier, Norfolk, England.

Large areas of the remaining wetland in the United Kingdom are faced with virtual extinction because of the pressures engendered by high productivity farming practices, reinforced by subsidized land drainage and flood protection schemes as well as by price supports for agricultural produce in the European Economic Community. Unique environmental resources are being put at risk by changing farming methods and in particular by arable conversion schemes. A case study, the Yare Barrier Proposal in Norfolk, is used to analyze and evaluate the environmental impacts of drainage and flood protection schemes on the surrounding wetland ecosystems. An opportunity cost model is used to estimate the costs and benefits involved in this policy decision on preservation versus development. The case for the agricultural development of the wetlands made on the grounds of economic efficiency is not a strong one. (Author's abstract)
W84-02638

FORECASTING THE IMPACTS OF GLOBAL FORCES ON AMERICA'S WETLANDS,
Fish and Wildlife Service, Washington, DC.
For primary bibliographic entry see Field 2L.
W84-02682

SOURCES OF NITRATES IN GROUNDWATER OF THE COASTAL PLAIN OF ISRAEL; EVOLUTION OF IDEAS,
Ministry of Agriculture, Tel-Aviv (Israel).
For primary bibliographic entry see Field 5B.
W84-02700

THE EFFECTS OF IMPOUNDMENT ON THE DOWNSTREAM MACROINVERTEBRATE RIFFLE FAUNA OF THE RIVER ELAN, MID-WALES,
Welsh Water Authority, Powys (Wales).
R. J. Inverarity, G. D. Rosehill, and M. P. Brooker.
Environmental Pollution (Series A), Vol. 32, No. 4, p 245-267, 1983. 5 Fig, 5 Tab, 37 Ref.

Descriptors: *Dam effects, *Invertebrates, *River Elan, *River Wye, *Wales, Iron, Manganese, Hydrogen ion concentration, Riffles, Coleoptera, Ephemeroptera, Trichoptera, Effluents, Environmental effects.

River water quality and hydrological regime in the River Elan, downstream of an impoundment in an upland catchment in mid-Wales, were considerably different from a nearby naturally flowing river. Concentrations of total iron (mean, 0.26 and 0.61 mg/l in May and September) and manganese (mean, 0.12 and 0.16 mg/l) were elevated in the River Elan compared with the nearby River Wye (iron $<$ or $=$ 0.16 mg/l, manganese $<$ or $=$ 0.01 mg/l). pH in the River Elan (5.3 - 5.5) was considerably lower than the naturally flowing River Wye (6.9 7.2). There were differences in riffle macroinvertebrates, generally collected with a cylinder sampler on two occasions, in the Elan and Wye. A number of taxa were not recorded or were found at relatively low densities in the River Elan: principally these included representatives of the Coleoptera, Ephemeroptera and Trichoptera. Additionally, total densities in the River Wye (mean, 4900/sq m in May) were significantly ($p<0.05$) higher than the Elan (mean, 900/sq m in May). There was no evidence that effluents discharging to the Elan affected the distribution of macroinvertebrates. Differences between the fauna of the impounded River Elan and the naturally flowing River Wye probably resulted from the presence of iron- and manganese- rich deposits in the River Elan - probably derived from metal-rich water from the reservoir - although reduced pH and water temperature downstream of the impoundment could have contributed to the paucity of the fauna. (Author's abstract)
W84-02787

GROUND WATER FOR OIL-SHALE DEVELOPMENT, PICEANCE BASIN, COLORADO,
Geological Survey, Reston, VA.
W. M. Alley.
Ground Water, Vol. 21, No. 4, p 456-464, July-August, 1983. 6 Fig, 1 Tab, 23 Ref.

Descriptors: *Groundwater potential, *Oil shale, *Groundwater management, *Piceance Basin, *Colorado, White River, River basins, Streamflow, Model studies, Reservoirs.

Vast deposits of oil shale are contained in the Piceance basin in northwestern Colorado. Development of this resource will require a large amount of water. A synthetic streamflow model was used to investigate the effects of using conservative estimates of groundwater on the required active storage capacity of a hypothetical reservoir on the White River. The use of groundwater from mine drainage and/or auxiliary wells may have a significant impact on the size and timing of surface-water reservoirs. Thus, groundwater may be an important source of supply, particularly during early development of an oil-shale industry. Further study is needed on the physical availability of groundwater as well as the institutional, legal, and water quality constraints on its use. An important part of the current study was a monthly mass balance of reservoir storage. Reservoir losses due to evaporation and seepage were not included in the mass balance. (Baker-IVI)
W84-02806

PUMPING EFFECTS OF WELLS IN FRACTURED GRANITIC TERRAIN,
British Columbia Ministry of Environment, Victoria.
A. P. Kohut, J. C. Foweraker, D. A. Johanson, E. H. Tradewell, and W. S. Hodge.
Ground Water, Vol. 21, No. 5, p 564-572, September-October, 1983. 14 Fig, 2 Tab, 12 Ref.

Descriptors: *Wells, *Geologic fractures, *Granite, *Pumping, Drawdown, Bedrock, Groundwater supplies, Line sinks, Saanich Peninsula, British Columbia.

Pumping from large-capacity bedrock wells in the granitic terrain of the Saanich Peninsula (British Columbia) results in the development of trough-like cones of depression of marked linearity (line sinks) which may extend more than 1,500 m (4,900 ft) from the pumped wells. The longitudinal axes of the drawdown troughs do not parallel major areal fracture directions, but develop along trends coinciding with the areal intersections of the two prominent bedrock joint sets prevalent in the region and bisect the angels between the sets. The drawdown troughs extended preferentially away from the pumped wells toward local recharge areas in a general direction of increasing regional potentiometric head. This phenomenon may be in part coincidental, as a sufficient number of observation wells were not available downgradient from the pumping wells to delineate the full extent of the drawdown trough. It is likely that the major controls on trough development are related to the orientation, spacing, dimensional characteristics, degree of connectivity and permeability of fractures rather than the regional potentiometric gradient. Occurrence of this line sink phenomenon indicates that fracture anisotropy in granitic terrain has a pronounced effect on the magnitude and direction of drawdown interference about a pumped well. Apart from apparent fracture heterogeneity in the granitic mass, there is yet evidence of hydraulic continuity on a regional scale as indicated by water level responses in the observation wells. (Baker-IVI)
W84-02809

EFFECTS OF AQUIFER INTERCONNECTION RESULTING FROM UNDERGROUND COAL GASIFICATION,
Lawrence Livermore National Lab., CA.
For primary bibliographic entry see Field 2F.
W84-02813

7. RESOURCES DATA

7A. Network Design

HOW TO CONSTRUCT REFERENCE DISTRIBUTIONS TO EVALUATE TREATMENT PLANT EFFLUENT QUALITY,
Wisconsin Univ.-Madison. Dept. of Civil and Environmental Engineering.
P. M. Berthouex, and W. G. Hunter.
Journal of the Water Pollution Control Federation, Vol. 55, No. 12, p 1417-1424, December, 1983. 8 Fig, 2 Tab, 1 Ref. EPA grant R809162010.

Descriptors: *Effluents, *Water quality control, *Statistical analysis, Mathematical studies, Statistical methods, Reference distribution, Wastewater treatment, Wastewater treatment facilities, Decision making, Management.

Much time and money are spent making measurements of treatment plant performance. The data should be processed in a way that makes them informative and lead the operator in generally profitable directions. Preferred methods of processing the data are simple, yet statistically valid and useful. The reference distribution is a statistically valid tool which can be derived for any statistic that might increase our understanding of the treatment process. In making the reference distribution, no assumptions about statistical properties of the data are needed. The reference distribution will usually be presented as a histogram, which is a clear picture of what is expected and what is unusual. This picture can be embellished by marking warning levels; for example the levels exceeded only 1 or 5% of the time. The 5% warning level on the reference distribution is robust with respect to selection of the stable and upset portions of the data series. The 1% level will be more sensitive to inclusion or rejection of high values, but subjective selection of the stable periods is acceptable. Incoming data, or statistics calculated from these data, are tested against the warning levels. An alert signaled by the 1% level almost certainly means that plant performance has changed. The 5% warning level gives an alert signal about one day out of twenty, even when the plant is operating in a stable fashion. The reference distribution is a simple graphical tool that is easy to devise and easy to use. Despite its simplicity, it is statistically valid and powerful. (Baker-IVI)
W84-02605

DATA ACQUISITION NETWORKS,
Institut National de la Recherche Scientifique, Sainte-Foy (Quebec).
D. Couillard.
Journal of Environmental Systems, Vol. 13, No. 1, p 43-57, 1983-84. 1 Fig, 2 Tab, 26 Ref.

Descriptors: *Data acquisition, *France, *Belgium, *Networks, Governmental interrelations, Water demand, Water resources.

Studies concerning water resources are a central preoccupation in the majority of developed countries. Data acquisition is an important part of these studies. Data acquisition networks are very costly, and it is imperative that any investments made will yield the desired results. The methods of data acquisition currently in effect in Belgium and France were analyzed. Belgium has a very large problem with water. Although the country has a fairly humid climate and abundant precipitation, consumer demand for water becomes critical in dry years, due to the high population density, the high degree of industrial and agricultural development and the constant need for water in the ship canals. These problems fall within the purview of four ministries: Public Works; Agriculture; Public Health; and Economic Affairs. In 1965, a water commission (Commissariat Royal au Probleme de l'Eau) was set up. It had the responsibility of coordinating all work in this area and assumed the following objectives: make an inventory of water requirements and resources; study the most urgent problems and suggest measures to overcome them; make up a national balance sheet of requirements and resources with a view to establishing a coherent water policy. In France, responsibility in the area of water resources is divided among the Ministries of Agriculture, Industrial and Scientific Development, Economic Affairs, Public Works, Public Health, the Ministry of the Interior and Electricite de France. The permanent water secretariat (SPPE) has the task of setting up an inventory of data and routing the data to users. The center for engineering design and technology research in agriculture, forestry and rural works (CERAFER) organizes studies of rivers and wastes through the regional water management service (SRAE). (Moore-IVI)
W84-02681

7B. Data Acquisition

BIOASSAY EVALUATION OF DIVERSITY AND COMMUNITY COMPARISON INDEXES,
Alabama Univ. in Birmingham. School of Public Health.
For primary bibliographic entry see Field 5C.
W84-02570

EVALUATION OF A SAMPLER FOR LIQUID EFFLUENTS,
Imperial Chemical Industries Ltd., Brixham (England). Brixham Lab.
For primary bibliographic entry see Field 5D.
W84-02699

AN IMPROVED TECHNIQUE FOR ESTIMATING MEAN DEPTH OF LAKES,
Corvallis Environmental Research Lab., OR.
For primary bibliographic entry see Field 2H.
W84-02707

SAMPLING FREQUENCY FOR WATER QUALITY MONITORING: MEASURES OF EFFECTIVENESS,
Nichols Applied Management, Edmonton (Alberta).
For primary bibliographic entry see Field 5A.
W84-02757

MEASURING WATER SURFACE AND STREAMBED ELEVATION CHANGES WITH THE ACOUSTIC VELOCITY METERING SYSTEM,
Geological Survey, Portland, OR. Water Resources Div.
For primary bibliographic entry see Field 2E.
W84-02771

HYPOTHESIS-TESTING BY MODELLING CATCHMENT RESPONSE,
Hull Univ. (England). Dept. of Geography.
For primary bibliographic entry see Field 4C.
W84-02899

INTERFACING SOIL MOISTURE GYPSUM BLOCKS WITH A MODERN DATA-LOGGING SYSTEM USING A SIMPLE, LOW-COST, DC METHOD,
Institute of Hydrology, Wallingford (England).
I. C. Strangeways.
Soil Science, Vol. 136, No. 5, p 322-324, November, 1983. 7 Fig, 2 Ref.

Descriptors: *Soil water, *Gypsum blocks, *Data-logging system, *Costs, *Direct current, On-site data collections, Gypsum, Soil tension, Soil pressure, Economic efficiency.

Gypsum blocks are useful in field studies of soil moisture as low-cost, if only moderately precise, sensors of soil tension that can be used over a wide range of tensions, unlike manometer or pressure transducer sensors, which are limited to the lower ranges of tension. The development enabled gypsum blocks to be read by a modern data-logging system. It differs from conventional AC methods in using a short-duration DC pulse, thus permitting a simple, low-cost circuit of high stability to be used. The work was done originally to detect the passage of wetting fronts in an arid climate; its application is, however, general. (Murphy-IVI)
W84-02909

BRASS MODEL: PRACTICAL ASPECTS,
Army Engineer District, Savannah, GA.
G. F. McMahon, R. Fitzgerald, and B. McCarthy.
Journal of Water Resources Planning and Management, Vol. 110, No. 1, p 75-89, January, 1984. 6 Fig, 10 Ref.

Descriptors: *Computer models, *Basin Runoff and Streamflow Simulation, *BRASS, Computer programs, Computers, Hydrologic/hydraulic model, Rainfall simulators, Runoff, Flood forecasting, Flood plain management, Savannah River.

The BRASS (Basin Runoff and Streamflow Simulation) model provides flood management decision support for operation of Savannah River system projects. BRASS is an interactive hydrologic/hydraulic model which can perform rainfall-runoff simulation for subareas, using the Soil Conservation Service curve number infiltration procedure, continuously simulate variation in curve number and baseflow for subareas using rainfall and evaporation data, perform unit hydrograph and controlled storage routing of subarea runoff, and perform dynamic streamflow, routing for combining subarea outflows and determining stage, discharge, and velocity histories at points throughout a dendritic river system. The model incorporates and enhances two previously developed hydrologic models and the National Weather Service river forecast model, DWOPER, linked by a command program using 'problem-oriented language' (POL) input. Because BRASS effectively merges hydrologic and hydraulic models for watershed analysis, it has numerous applications in project operations, flood forecasting (including tidally influenced areas), and design of flood or water control structures. (Murphy-IVI)
W84-02921

7C. Evaluation, Processing and Publication

STATISTICAL MODELS FOR WATER QUALITY REGULATION,
Colorado State Univ., Fort Collins. Dept. of Agricultural and Chemical Engineering.
For primary bibliographic entry see Field 5G.
W84-02577

EXPERIENCES WITH AUTOMATED INFORMATION RETRIEVAL,
Vakgroep Gezondheidstechniek, Delft (Netherlands). Afdeling der Civiele Techniek
H. H. Siebers, and M. W. de Jong-Hofman.
Water Research, Vol. 17, No. 12, p 1715-1719, 1983. 6 Tab, 3 Ref.

Descriptors: *Information retrieval, Water supply, Wastewater treatment, Surface water, Information systems, Bibliographies.

There are two basically different ways to retrieve publications dealing with subjects in the field of water supply, wastewater treatment and surface water: manual and online. Manual searching contains amongst others reading professional journals and bibliographies or abstract journals. With the aid of a computer it is possible to search online in bibliographic data bases. This article mainly deals with online searching. In two practical examples results and expenses are put together. In order to execute a search as complete as possible online searching in several data bases is required. From the results of the searches and from reading the original literature, it is obvious that, if possible and done with special care, manual searching produces more references than online searching. (Author's abstract)
W84-02716

COMPUTATIONAL MODEL FOR THE OHIO RIVER CHUTES AT LOUISVILLE: THE 1972 VIRGIN CONDITIONS,
A. Giorgini, and A. Rinaldo.
Instrument Society of America Transactions, Vol. 22, No. 4, p 55-68, 1983. 12 Fig, 2 Tab, 10 Ref.

Descriptors: *Model studies, *Ohio River, *River chutes, Kentucky, Indiana, River flow, Legal aspects, History, Hydraulic models.

The need for simulation and modeling of the hydraulic behavior of the Ohio River at Louisville's Chutes in the 1792 conditions arose from a legal dispute between Kentucky and Indiana. On June 1st, 1792 when Kentucky was admitted to the Union, its northern boundary was declared to be

the north bank of the river Ohio at low water mark. The same line became the Indiana southern boundary when that state was created on December 11, 1816. Since the 1792 low water mark could not be determined with certainly, the 1895 low water mark was taken was a conservative substitute for it. The 404.7 ft 1895 low water mark was affected by a wing dam whose removal, to restore the 1792 condition lowered the water level to 403.7. There is a definite probability that in 1792 at low waters, Six Mile Island was an Indiana peninsula. It is emphasized that this result demonstrated first within the hydraulic research context by means of computer graphics would be a certainty under the condition that the Knox-Wayne correspondence were interpreted to apply to almost dry conditions along the Chutes. (Baker-IVI)
W84-02932

8. ENGINEERING WORKS

8A. Structures

CHARACTERISTICS OF THE DESIGN AND CONSTRUCTION OF HYDRAULIC-FILL STRUCTURES ON EXISTING RESERVOIRS,
V. F. Kanarskii, V. M. Kondrat'ev, V. A. Ivanon, and M. I. Rogoza.
Hydrotechnical Construction, Vol. 17, No. 3, p 131-136, March, 1983. 5 Fig, 4 Tab, 7 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 3, p 24-26, March, 1983.

Descriptors: *Dam construction, *Design criteria, Reservoirs, Hydraulic fill, Construction, Powerplants, Zaporozhe nuclear power plant, Balakov nuclear power plant, Nuclear energy.

Characteristics of the design and construction of the dams of the cooling ponds of the Zaporozhe and Balakov nuclear power stations on the reservoirs of the Kakhovka and Saratov hydroelectric stations are discussed. The construction of hydraulic-fill structures detaching individual water areas on existing reservoirs is related to the danger of waves eroding these structures, especially in deep stretches of the reservoirs. The experience of constructing and operating hydraulic-fill structures with a flattened profile shows that their hydrodynamic stability and strength depend on wind and wave action, size and composition of the earth material, and shape of the shoreline being formed by the structure being constructed, and other factors. Correct consideration of the indicated factors and generalization of the experience of operating objects-analogs makes it possible to obtain substantiated engineering solutions when designing and constructing structures for enclosing deep areas on existing reservoirs. (Baker-IVI)
W84-02646

SEISMIC STRESSED STATE OF UNDERGROUND HYDRAULIC STRUCTURES AT THE ROGUN HYDROELECTRIC STATION,
D. V. Monakhenko, Ya. N. Tsukerman, and S. G. Shul'man.
Hydrotechnical Construction, Vol. 17, No. 4, p 151-155, April, 1983. 3 Fig, 8 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 4, p 13-16, April, 1983.

Descriptors: *Design criteria, *Hydraulic structures, Dams, Powerplants, Hydroelectric powerplants, Seismic properties, Rogun Hydrostation.

The seismic stressed state of a number of underground hydraulic structures was investigated, in particular, one of the variants of the structures of the powerhouse (PHC) complex of the Rogun hydrostation was examined. The structures of the PHC are located in soft rocks and consist of a number of parallel workings of large cross section with a horseshoe configuration with a length of more than 200 m. The mass adjacent to the workings of the rooms of the PHC under seismic actions directed perpendicular to the longitudinal axes of the workings is under conditions of plane strain and the problem reduces to the two-dimensional problem in elasticity theory for a multiply connected region. The PHC of the Rogun hydrostation is located in the vicinity of the Vakhsh River canyon, and thus it was necessary to take into account the presence of a free surface of complex profile. The work undertook to determine the stresses in linings and interchamber pillars under seismic actions directed perpendicular to the longitudinal axis of the workings. The experiments were conducted for several variants of the direction of wave propagation. Interpretation of the optical patterns consisted in constructing time dependences of the contour stresses on the boundaries of the workings and the sum and difference of the principal stresses. (Baker-IVI)
W84-02647

CONSIDERATION OF THE WORK OF ELASTIC AND INERTIAL FORCES OF THE FOUNDATION WHEN DETERMINING SEISMIC LOADS FOR THE DAM OF THE KURPSAI HYDROELECTRIC STATION,
V. N. Lombardo.
Hydrotechnical Construction, Vol. 17, No. 4, p 156-165, April, 1983. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 4, p 16-23, April, 1983.

Descriptors: *Dam construction, *Seismic properties, *Design criteria, Dams, Construction, Elastic properties, Hydroelectric powerplant, Powerplants, Kurpsai Hydroelectric Station.

The problems of considering the work of elastic and inertial forces as applied to the calculations of a section of a gravity dam are considered. The structure and region adjacent to it are considered to work under the conditions of the two dimensional problem in elasticity theory. The inertial load is determined under the condition of rigid restraint along the base and also in cases when the calculation scheme includes a region of the foundation of various dimensions. In order to take into account the work of elastic and inertial forces it is necessary to include in the calculation scheme a region of the foundation of considerable size. With such consideration of the effect of the foundation it is necessary to examine about 100 modes of free oscillations lying in the frequency range of the first four or five modes of oscillation of a cantilever beam. Correct consideration of the work of elastic and inertial forces of the foundation permits reducing the inertial load. With respect to the calculation of the Kurpsai dam this decrease was about 20-30% compared to the load determined by the beam scheme with consideration of elasticity of the foundation by Vogt's method. (Baker-IVI)
W84-02648

ACCURACY OF DETERMINING THE DESIGN VELOCITY IN POWER CONDUITS OF HYDROELECTRIC STATIONS,
V. A. Orlov.
Hydrotechnical Construction, Vol. 17, No. 5, p 213-224, May, 1983. 4 Fig, 3 Tab, 4 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 5, p 15-20, May, 1983.

Descriptors: *Design criteria, *Conduits, Powerplants, Hydroelectric plants, Velocity, Construction, Water velocity.

A change in the design velocity in power conduits even by a comparatively small amount leads to noticeable changes in capital investments in these structures. This is especially true for long diversion conduits and penstocks. The design velocity in power conduits of hydroelectric stations is determined from the condition of minimum calculated expenditures on the following components: the power conduit, the structures linked to it, the substituting thermal power station, and its fuel resources. With an increase of the velocity in the conduit, the calculated expenditures on the conduit and linking structures decrease and the expenditures on the thermal power station and fuel resources increase. The design water velocity in conduits should be assigned with consideration of the linking structures and possible variation of the calculated expenditures. It is expedient to go for an increase of velocity with consideration of construction works and standard diameters of the conduit. (Baker-IVI)
W84-02653

HYDRAULIC FILLING FOR CLOSING THE CHANNEL OF THE VOLGA AT THE SIDE OF THE CHEBOKSARY HYDROELECTRIC STATION,
N. A. Bychkov, N. K. Golubev, and M. S. Triandafilov.
Hydrotechnical Construction, Vol. 17, No. 5, p 225-231, May, 1983. 6 Fig, 2 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 5, p 20-24, May, 1983.

Descriptors: *Hydraulic fill, *Channel improvement, Channels, Dams, Cheboksary Hydroelectric Plant, USSR, Volga River, Earth dams, Construction, Rocks.

The use of hydraulic filling for closing the channel of the Volga at the site of the Cheboksary hydrostation showed that high productivity and efficient operation of suction dredges under severe weather conditions is possible with thorough performance of preparatory works on stockpiling soil and clearing construction trash from sections of cofferdams to be excavated. When closing river channels it is necessary to accomplish, as far as possible, maximum narrowing of the channel by hydraulic filling into the flow by dredges, which makes it possible to reduce the use of costly imported materials and to reduce the volume of hydraulic works before the start of the final stage of closing the channel. In the presence of a shuga run, the construction of a channel earth dam should be carried out with negligible lagging of the narrowing of the channel by hydraulic fill over the entire width behind the narrowing of the gap by a berm, with consideration of the volume of works, time of their performance, and selection of the appropriate means of mechanization. (Baker-IVI)
W84-02654

PROTECTION OF THE SLOPES OF EARTH DAMS DURING CONSTRUCTION OF TIDAL POWER STATIONS,
V. G. Yakovenko, and N. A. Tsymarnaya.
Hydrotechnical Construction, Vol. 17, No. 5, p 253-257, May, 1983. 4 Fig, 7 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 5, p 36-38, May, 1983.

Descriptors: *Earth dams, *Powerplants, *Slope protection, *Tidal powerplants, Dam construction, Construction, Design criteria, Tides, Slopes, Slope stabilization.

Tidal energy is being explored as a potentially economically advantageous source of energy. One characteristic is the constancy of its mean monthly potential in a long-term series. Its considerable presence in the White and Okhotsk Seas and also the favorable experience of new designs tested during the construction and 14 yr operation of the Kislaya Guba tidal power station made it possible to proceed to the planning of powerful tidal power stations in the Mezen and Penzhina bays and also an experimental tidal power station in the Kola Bay. Progressive new technological equipment has recently come into use in protecting dam slopes in marine hydrotechnical construction in the form of self-elevating platforms whose use when protecting the slopes of dams of a TPS can solve the problem of the continuous construction of revetments under open-sea conditions. Use of such self-elevating platforms is discussed. (Baker-IVI)
W84-02657

TEMPERATURE REGIME AND STATE OF THERMAL STRESS OF THE KURPSAI DAM,
K. I. Dzyuba, and N. I. Fradkina.
Hydrotechnical Construction, Vol. 17, No. 6, p 289-293, June, 1983. 3 Fig, 6 Tab, 3 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 6, p 11-14, June, 1983.

Descriptors: *Concrete dams, *Thermal stress, Temperature effects, Dams, Dam construction, Thermophysical characteristics, Tensile stresses, Kurpsai Dam, USSR.

For the examined thermophysical characteristics of the concrete and foundation and conditions of con-

structing the Kurpsai Dam, the absence of insulation on the downstream face leads to the occurrence of considerable tensile stresses both in the outside and interior zones of the dam. In this case it should be expected that a disturbance of the solidity in the outer zones of the dam will occur even in the construction period both on the downstream and upstream faces, primarily opening of the block joints which have a low tensile strength of the concrete, which is confirmed by on-site observations conducted during construction of the dam. In the central part of the dam the tensile stresses in the construction period do not exceed the tensile strength of the concrete. In the opening period the horizontal tensile stresses in the interior zones of the dam are close to the tensile strength of the concrete. Under these conditions special attention should be given to providing the specified tensile strength of the concrete to avoid the occurrence of vertical cracks in the middle of the dam. In connection with the low tensile strength of the horizontal block joints considerable vertical tensile stresses occurring in the interior zones of the upper part of the dam in the operating period can lead to their opening. (Baker-IVI)
W84-02661

SOILS AND METHODS OF CONSTRUCTING EARTH DAMS,
A. A. Borovoi, L. P. Mikhailov, I. S. Moiseev, and V. G. Radchenko.
Hydrotechnical Construction, Vol. 17, No. 6, p 333-339, June, 1983. 5 Fig, 1 Tab, 11 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 6, p 45-49, June, 1983.

Descriptors: *Earth dams, *Dam construction, Soil properties, Design criteria, Soil types, Strength, Argillite, Siltstone, Shales, Rocks, Regulations, USSR.

Earth dams are becoming increasingly more prevalent in Russia, especially in regions with a harsh climate and in difficult accessible mountainous regions. High earth dams are important engineering structures. The type of earth dam to be built is determined primarily by the presence of soils in the construction region suitable for its construction. For almost any site a dam can be designed with a soil or nonsoil watertight element in which nearby soils could be used, especially with consideration of the fact that the majority of soils, including waterlogged, low-strength, weathered, and even coal-mining wastes, are presently being used. The use of low strength soils from rocks of the type argillite, siltstone, shales and the like in the construction of dams in many cases permits a substantial reduction of their cost and construction time. Field and on-site investigations of the weatherability of low-strength soils showed that no noticeable change in the particle-size distribution occurs in the compacted material under the effect of atmospheric agents. In certain cases the use of waterlogged soils with consideration of the construction of drainage layers is considered expedient for the body of earth dams or cores of rock-earth dams. The maximum allowable settlements of high dams owing to the complexity of joining individual zones with each other and with the base and walls of the canyon are usually limited to control cracking. Limitation of the deformability of cores of high dams necessitates their preliminary preparation by enrichment, mixing of various soils, removal of large stones, drying soils or their additional wetting. Technological methods of constructing dams are constantly being improved. Along with the widely used methods of layer-by-layer construction of dams by means of hydraulicking, placing soil in water and construction by directed blasting is promising. (Baker-IVI)
W84-02665

ENGINEERING WATER WELLS,
Central Utah Water Conservancy District, Orem.
C. H. Carpenter.
Journal of the American Water Works Association, Vol. 75, No. 8, p 395-397, August, 1983. 3 Fig, 1 Tab, 4 Ref.

Descriptors: *Wells, *Construction, Decision making, Planning, Design criteria, Energy, Costs, Financial aspects, Test wells.

Groundwater users should seek to obtain the most efficient wells possible by means of hydrogeologic investigations as energy costs continue to rise. Applied engineering and investment in a test hole provide the best possible design for a satisfactory and long term water well that will produce satisfactory quantities of water with minimal operating costs. Applied engineering and investment in a test hole provide the best possible design for a satisfactory and long term water well. First, a thorough geohydrologic study is made to locate the best site. Then the services of an engineer are sought to design the well properly. After the well is constructed and properly developed, a pumping test is conducted to determine long term performance and to design the pump. The basic objective in water well construction is to maximize the opening to allow water to flow from the water bearing formation to the pump and still retain the formation material outside the casing of the well. It is noted, however, that no matter how much geohydrology goes into well location or how much engineering is provided to design water wells, successful wells still depend to a large extent on the skill of the well driller. (Baker-IVI)
W84-02668

ENERGY EFFICIENCY THROUGH PIPE DESIGN,
Army Engineer Waterways Experiment Station, Vicksburg, MS.
T. M. Walski.
Journal of the American Water Works Association, Vol. 75, No. 10, p 492-495, October, 1983. 6 Fig, 1 Tab, 6 Ref.

Descriptors: *Pipelines, *Economic aspects, *Decision making, Planning, Management, Water supply, Design criteria.

Some simple rules that incorporate energy cost factors into the selection of pipe sizes during development of planning studies are presented. The correct way of determining optimal pipe size is to choose several candidate pipe sizes, to calculate pumping and energy requirements for each size based on peak flow, to determine actual flows during the life of the pipe, to determine system head curves and pump characteristic curves, and then to compare the life-cycle costs of various pipe sizes. The final selection is an economic one of minimizing life cycle costs while meeting the needs of the system under study, including environmental, legal, fiscal, and institutional constraints. The amount of data needed includes flows (peak, average, and minimum), length of pipe, elevations, required heads, pipe type, energy costs, labor rate, interest rate, design life, number of pumps, depth of cover, and amount of excavation occurring in rock. (Baker-IVI)
W84-02674

COMPARISON OF 2-D AND 3-D DYNAMIC ANALYSES OF EARTH DAMS,
Harding-Lawson Associates, Novato, CA.
L. H. Mejia, and H. B. Seed.
Journal of Geotechnical Engineering, Vol. 109, No. 11, p 1383-1398, November, 1983. 12 Fig, 17 Ref. NSF grant PFR-7918267.

Descriptors: *Dynamic response analysis, *Earth dams, Stress analysis, Rheology, Dynamic stress, Shear stress, Plane strain, Two-dimensional models, Three-dimensional models, Earthquakes, Oroville dam.

Considerable judgment is required to estimate the overall three-dimensional dynamic response to a dam in a narrow canyon from plane strain analyses of individual sections of the dam. Three-dimensional and two-dimensional dynamic analyses of two dams with different canyon geometries are compared. Oroville Dam and a hypothetical dam with the same main section as Oroville Dam but in a narrower canyon are the focus of the analyses. The plane strain analysis of the maximum section of Oroville Dam have values for the shear stresses that were within 20% of those computed from a three-dimensional analysis of the dam. Accelerations were found to be more sensitive to the boundary conditions and, therefore, less accurately computed from a two-dimensional analysis than stresses. Similar conclusions were made in regard to the plane strain analysis of the quarter section of the dam. For dams in steeper canyons than that of Oroville Dam, plane strain analyses of the maximum section and the quarter section of the dam apparently cannot simulate correctly the behavior of the embankment. It is necessary in those cases to perform three-dimensional analysis to obtain satisfactory results for design purposes. (Murphy-IVI)
W84-02825

IMPROVED RISK AND RELIABILITY MODEL FOR HYDRAULIC STRUCTURES,
Texas Univ. at Austin. Dept. of Civil Engineering.
H.-L. Lee, and L. W. Mays.
Water Resources Research, Vol. 19, No. 6, p 1415-1422, December, 1983. 11 Fig, 16 Ref.

Descriptors: *Hydraulic structures, *Model studies, Construction, Risks, Decision making, Planning, Water management, Water resources development, Economic aspects.

Improved dynamic risk and reliability models based on conditional probability distributions are developed. The new dynamic risk model reflects more accurately the overall risk (probability of failure considering both hydrologic and hydraulic uncertainties) of a hydraulic structure. This dynamic risk model is also shown to have a close correspondence to nonparametric methods for evaluating the exceedance probability of a hydrologic event. Generally the return period of a flood with certain magnitude for the design criteria is not known exactly. The time period estimated from the limited sample observations might lead to a biased estimate for the return period of such a flood. The new dynamic risk model can lead to the improved design of flood prevention measures. The risk models developed can be applied to other types of hydraulic structures, such as bridges, storm sewers, and channels. (Baker-IVI)
W84-02845

WATER SUPPLY SYSTEM DESIGN INVOLVES MANY TECHNOLOGIES,
Burns and McDonnell, Kansas City, MO.
R. D. Vering, D. J. Langford, and K. M. Neuschwander.
Power Engineering, Vol. 87, No. 12, p 44-46, December, 1983.

Descriptors: *Water conveyance, *Design criteria, Powerplants, Pipelines, Reservoirs, Pumps, Valves, Utah, Green River, Cooling water, Corrosion control, Water hammer.

An 800-MW power plant was planned for construction in Utah at a point 20 miles to the southeast of the Green River, which was to serve as the major source of water for the plant. A single pipeline was designed to supply the water needs. Maximum plant demand has been projected to be 27 cu ft/sec based on the plant's two-unit evaporative wet cooling tower needs. Surface-type diversion method could not be used because of severe environmental problems and river characteristics which included low gradient, heavy sediment load, migrating channel and sand bars, shallow depth, and winter icing problems. Pumping scheme selection was of primary importance because of the need to lift the water more than 1000 ft from the Green River to a high-point reservoir. System control complexity was reduced by using two reservoirs to accommodate flow variations and provide capacity to allow for reaction time during a system upset. Flow in the gravity-flow line portion of the pipeline is controlled by discharge control valves installed at the bottom of the downhill line. The problem of water hammer was analyzed and controlled. Impressed current corrosion as well as galvanic corrosion were major design considerations and several steps were taken to enhance the corrosion resistance capabilities of the water supply line. Concrete pipe joints were bonded to provide electrical continuity. (Baker-IVI)
W84-02904

8B. Hydraulics

CHARACTERISTICS OF A STUDY OF THE PHYSICAL AND MECHANICAL PROPERTIES OF MEALY DOLOMITES IN HYDROTECHNICAL CONSTRUCTION,

N. F. Aripov, S. V. Bortkevich, and A. N. Skibin.

Hydrotechnical Construction, Vol. 17, No. 4, p 166-171, April, 1983. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 4, p 23-26, April, 1983.

Descriptors: *Dolomite, *Physical properties, *Dam construction, Earth dams, Construction, Soil engineering, Soil properties, Soil compaction.

The compressibility of the soil by static loads under drained conditions was estimated using a cylindrical press mold with a cross-sectional area of 40 sq cm at various water contents. Soil strength was studied in direct and triaxial shear apparatus on cylindrical specimens with a cross-sectional area of 40 sq cm. An essential characteristic of mealy dolomites is the rapid realization of settlement during loading, which makes them similar to sands. When studying the properties of mealy dolomites as a material of earth dams and embankments of hydraulic structures it is necessary to take into consideration that the structure of the artificially compressed dolomite soil has a substantial effect on its physical and mechanical characteristics. Dolomite soil compressed with a water content higher than the optimal has a mobil structure, promoting an increase of its compressibility and self-strengthening in shear due to repacking of the mineral particles. The difference in the structures and deformation properties of saturated dolomitic soil compressed at an optimal water content and water content higher than the optimal is observed in the range of values of the unit dry weight 1500-1950 kg/cu m, beyond the limits of which they become the same. (Baker-IVI)
W84-02649

HYDRAULIC RESISTANCES AND OPTIMAL DIMENSIONS OF STREAMFLOW DIVERSION CANALS,

I. F. Karasev.

Hydrotechnical Construction, Vol. 17, No. 4, p 175-180, April, 1983. 2 Fig, 14 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 4, p 29-33, April, 1983.

Descriptors: *Hydraulic properties, *Canals, *Streamflow, Design criteria, Resistance, Diversion canals.

Additional theoretical and empirical substantiations of the calculated hydraulic relations of artificial canals are needed with consideration of a set of factors determining the capacity of large canals. The dependence of resistance on the channel form factor b has been known for a long time, but its quantitative estimates are quite contradictory. To take into account the relative width factor one of the integral laws of hydrodynamics, the momentum theorem, has been applied to the usual hydraulic schematization of a flow with main dimensions R and specific wetted perimeter. For conditions of large canals it appears that the loss of dynamic stability of the flow is accompanied by reorganization of its kinematic structure and channel morphology. Two zones of maximum velocity appear in the cross section - a sign of integral separation of the flow into macrojets. The bottom relief also undergoes a change. Instead of a more or less ordered system of ribbon ridges, barchan-type ridges form. A relation is observed between the form parameters and the steepness of the ridges. Under certain conditions the ridge formations take the form of dunes, inducing the channel to meander. A shift of the channel line creates zones of pressing of the flow toward the banks and centers of their erosion, supplying the flow with sediments, which activates still more the side erosion process that occurred. Deformation can take on a progressive uncontrollable character, if engineering measures limiting its development are not provided for. (Baker-IVI)
W84-02650

CAUSES OF RIVER BED DEGRADATION,

V. J. Galay.

Water Resources Research, Vol. 19, No. 5, p 1057-1090, October, 1983. 44 Fig, 3 Tab, 77 Ref.

Descriptors: *Bed degradation, *River beds, River slope, Flow discharge, Bed material, Control points, Tributaries, Upstream, Downstream, Flood damage.

River bed degradation can proceed downstream as well as upstream depending upon the cause of degradation. The causes of downstream progressing degradation are primarily related to changes in independent river channel variables, such as increase in water discharge, decrease in size of bed material, and decrease in bed material discharge. Upstream progressing degradation is generally caused by an imposed increase in river slope, which may be achieved by lowering a base level, such as in a lake or main river, or by decreasing the river length by removing a control point. Upstream progressing degradation, in general, develops more quickly than downstream progressing degradation. Downstream and upstream progressing degradation may occur within the same river reach at the same time. Any type of degradation on a main river generally produces upstream progressing degradation on a tributary. The degradation of the tributary can interfere with the degradation process on the main river. Degradation can occur very rapidly, within one flood event, and can proceed for many kilometers up or down a river. The design of water resource projects should include a careful analysis of all possible degradation processes along the main river, as well as along major tributaries. (Moore-IVI)
W84-02753

INFLUENCE OF THE POINT BAR ON FLOW THROUGH CURVED CHANNELS,

W. E. Dietrich, and J. D. Smith.

Water Resources Research, Vol. 19, No. 5, p 1173-1192, October, 1983. 20 Fig, 2 Tab, 50 Ref.

Descriptors: *Point bars, *Channel flow, *Channel curves, Shoaling, Flow velocity, Shear stress, Meanders, Cross-stream flow, Boundary conditions, Flow acceleration, Bottom topography, Water surface slope.

In a channel with bed topography that does not vary in the downstream direction, a secondary circulation composed of outward flow at the surface and inward flow near the bottom extends across the entire width. If the curvature is constant, the cross-stream velocity component near the bed and the pattern of boundary shear stress can be estimated by assuming fluid accelerations to be small. Unfortunately, this procedure cannot be used in analyzing the flow through natural river meanders, or through channels with downstream constant bottom topography but with rapidly changing curvature. In these latter cases, effects arising from bed- and bank-induced momentum changes must be accounted for. Evidence for a substantial topographically induced alteration in the cross-stream flow pattern relative to that for the analogous constant bottom topography case is provided through new analyses of several sets of laboratory and field data. Shoaling over the point bar in the upstream part of the bend is shown to force the high-velocity core of the flow toward the pool. This is accomplished by a convective acceleration-caused decrease in the cross-stream water surface slope and a resulting dominance of the vertically averaged centrifugal force. The primary effect is a velocity component toward the outside or concave bank throughout the flow depth over the upstream, shallow part of the point bar and an outward component of boundary shear stress in this region. The channel curvature-induced inward component of boundary shear stress consequently is confined to 20 or 30% of the channel width at the pool. Outward transfer of momentum over the point bar, as manifested by a rapid crossing of the high-velocity core from the inside bank to the outside one, contributes to an enhanced decrease in boundary shear stress along the convex side of the stream as the top of the bar is approached. Forces arising from topographically induced spatial accelerations are of the same order of magnitude as the downstream boundary shear stress and water surface slope force components, so they must be modeled as zero-order, not first- or second-order, effects. (Author's abstract)
W84-02762

LINING TUNNELS: TOUGHEST CONCRETING JOB.

Civil Engineering, Vol. 53, No. 11, p 60-61, November, 1983. 1 Fig.

Descriptors: *Concrete, *Tunnels, *Construction, Linings, Tunnel linings, Design criteria, Water conveyance, Water distribution, New York City.

The newest water supply tunnel in New York City is being constructed with exceptionally careful inspection and testing to be sure specifications are met. The lining of the 24 ft diameter tunnel was cast at least 17 in thick. Three shifts placed an average of 700 cu yd per pouring day. The lining was placed in two phases. First, the invert was poured in sections using a screed forming system that was supported and moved from a trolley system suspended from the tunnel roof. In the second pass, 290 degrees of arch and sidewall were concreted using collapsible telescopic forms moved by a traveler riding on the invert. A team of 10 inspectors worked at the drophole and near the batch plant. There were another 10 inspectors in the tunnel. The tunnel is expected to remain watertight for up to 100 years. (Baker-IVI)
W84-02775

FACTORS IN STABILITY OF RELOCATED CHANNELS,

Geological Survey, Menlo Park, CA.
J. C. Brice.

Journal of Hydraulic Engineering, Vol. 109, No. 10, p 1298-1313, October, 1983. 6 Fig, 27 Ref.

Descriptors: *Channel relocation, *Highways, *Bank stability, Channel stability, Check dams, Channel slope, Erosion, Floods, Vegetation.

Channels are relocated by highway agencies to improve channel alinement at a bridge crossing, to accomodate a planned roadway location, or to avoid one or more crossings. Lateral and vertical stability are assessed for 100 unlined channels, in different parts of the United States, that were relocated by highway agencies 10 years or more before assessment. Median length of natural channel cut off by relocation is 50 times natural channel width, or about 2,100 ft (650 m). Of all the relocated channels, banks are assessed as stable at 78% and unstable at 22%; of the shorter relocated channels (less than 50 channel widths), banks are assessed as stable at 84% and no significant degradation was observed. Of the unlined alluvial channels without check dams or bedrock outcrops (70 sites), 6% showed evidence of degradation to a depth of less than 1.5 ft (0.5 m). Of the 17 sites with check dams, 35% showed evidence of degradation, to maximum depths in the range of 1-3 ft (0.3-1 m). After an initial period of adjustment, the relocated channels tend to have about the same stability as that of the prior natural channel. Most of the relocated channels are shorter than their corresponding segments of natural channel by factors ranging from 0.1-0.9, and their slopes are therefore greater. Increase in channel slope by relocation is not clearly related to instability; and stable channels of similar drainage area range widely in slope. Factors commonly associated with instability are: bends in channel; erodibility of bed-bank materials; floods of large recurrence interval; and instability of natural channel before relocation. Factors associated with channel stability are side slopes not greater than 2:1, check dams, growth of woody vegetation on banks, straightness of alinement, erosional resistance of bed-bank materials, and natural (or artificial regulation of discharge. (Moore-IVI)
W84-02865

MEANDER BENDS OF HIGH AMPLITUDE,

Minnesota Univ., Minneapolis.
G. Parker, P. Diplas, and J. Akiyama.

Journal of Hydraulic Enginering, Vol. 109, No. 10, p 1323-1337, October, 1983. 15 Fig, 19 Ref. NSF grant CEE 8204953.

Descriptors: *Meanders, *Alluvial rivers, *Bends, Mathematical equations, Amplitude, Kinematics, Bank erosion, Skewing.

Meander bends of high amplitude in alluvial rivers often display a high degree of coherency. The only analytical equation heretofore available to describe such bends is the sine-generated curve, which has no rigorous derivation in the context of rivers. Herein a nonlinear 'bend equation,' based on a dynamical description of flow in bends and a kinematical description of bank erosion, is used to describe channel migration. This equation admits solutions of constant amplitude that migrate downstream with constant speed. The solution at high amplitude displays a prominent skewing that reveals the direction of flow. At low amplitude, the solution reduces to the sine-generated curve. (Author's abstract)
W84-02867

TRANSIENT CAVITATING PIPE FLOW,
Michigan Univ., Ann Arbor.
V. L. Streeter.
Journal of Hydraulic Engineering, Vol. 109, No. 11, p 1408-1423, November, 1983. 14 Fig, 9 Ref. NSF grant 019974.

Descriptors: *Cavitation, *Fluid mechanics, *Pipe flow, Vapor pressure, Rarefaction wave, Vapor formation, Vaporous velocity, Shock fronts, Mathematical equations.

When a liquid column in a pipeline is pulled apart by the upstream velocity being less than the downstream velocity for a sufficient period of time, cavitating flow occurs over portions of the pipeline. The cavitating flow, with vapor pressure at its surface, is acted on by friction and by gravity (for sloping pipes). A method of calculating transient cavitating pipe flow is developed which attempts to follow the mechanics in a distributed fashion. The manner in which a rarefaction wave moves through the fluid causing vapor formation is described, and equations are developed for vaporous velocity and vapor fraction as functions of distance and time. The vaporous flow is consolidated by shock fronts of liquid at the vapor-liquid interfaces. Equations are developed to determine the speed of the shock fronts and the pressure rise across them. For those reaches having no vapor, the method of specified time intervals within the method of characteristics is utilized. A program which includes these concepts permits transients in piping systems to be calculated for several boundary conditions. The regular method of characteristics gives good results, with only the problem of determining whether the spikes are mathematical or real. (Moore-IVI)
W84-02869

COMPUTATION OF 3-D FLOW AND SHEAR IN OPEN CHANNELS,
Pittsburgh Univ., PA.
C.-L. Chiu, and G.-F. Lin.
Journal of Hydraulic Engineering, Vol. 109, No. 11, p 1424-1440, November, 1983. 8 Fig, 1 Tab, 7 Ref. NSF grant CEE 81-09440.

Descriptors: *Open-channel flow, *Flow velocity, *Shear stress, Mathematical models, Simulation, Spatial distribution, Hydraulic models.

A mathematical modeling technique is presented which is capable of simulating various patterns of primary flow velocity distribution which may have the point of maximum velocity on or below the water surface. The simulated primary flow isovels are then used as a coordinate system in hydrodynamic analysis, to develop equations to compute corresponding distributions of shear stress and secondary flow. The mathematical models developed can be used to determine interactions among the primary flow velocity, shear stress and secondary flow velocity which all have a three-dimensional distribution. The approach is essentially semi-empirical which uses a measured or simulated distribution of primary flow velocity. It is designed to facilitate practical applications in studying various process in open channels, such as diffusion and dispersion of sediment, local scour and deposit, bank erosion, changes in channel geometry, aggradation and degradation of channel bed, which require three-dimensional modelings. An application to a flow in a bend of a laboratory flume has shown that results of simulating the distributions of primary flow velocity and shear stress agree well with the measured data. Large discrepancies are found to exist between the computed and measured secondary flow velocities. However, it is still uncertain whether the discrepancies are entirely due to modeling and computational errors as the accuracy level of measured data is unknown. (Author's abstract)
W84-02870

APPROACH-FLOW EFFECTS ON DOWNPULL OF GATES,
Karlsruhe Univ. (Germany, F.R.). Inst. fuer Hydromechanik.
N. D. Thang, and E. Naudascher.
Journal of Hydraulic Engineering, Vol. 109, No. 11, p 1521-1539, November, 1983. 11 Fig, 1 Tab, 23 Ref, 2 Append.

Descriptors: *Approach flow, *Downpull, *Intake gates, Turbulence, Flow discharge, Flow around objects, Drag, Lift, Hydraulic models.

The effects of various approach-flow conditions upon the downpull, the local pressures, and the discharge characteristics have been investigated for intake gates. Laser-Doppler-Anemometry measurements near the separation point of the gate bottom permit detailed specification of turbulence conditions. The partly strong variation of downpull and discharge coefficient for the different approach flows considered is traced to the sensitivity of the separated-flow pattern near bluff bodies to freestream turbulence, and to changes in the mean-flow incidence. For the particular gate studied, local flow separation from a protruding bottom girder and the placement of a trash-rack-like grid at a short distance upstream from the gate are shown to yield opposite effects on the downpull coefficient as compared to mere freestream turbulence. In analogy to the observations of flows around prisms, two separated-flow regimes with and without reattachment are identified in the flow around the gate bottom, and the observed effects of turbulence on the downpull and discharge are interpreted in terms of changes in the separation patterns. The results can be generalized and applied to geometrical configurations other than those studied. (Author's abstract)
W84-02871

ASYMMETRIC PLANE FLOW WITH APPLICATION TO ICE JAMS,
Iowa Univ., Iowa City.
J.-C. Tatinclaux, and M. Gogus.
Journal of Hydraulic Engineering, Vol. 109, No. 11, p 1540-1554, November, 1983. 6 Fig, 1 Tab, 17 Ref, 2 Append. NSF grant CME 77-12176.

Descriptors: *Ice jams, *Plane flow, Turbulence, Flow velocity, Shear stress, Simulation, Mathematical equations, Friction, Roughness.

An available turbulence method is used to prove that in plane flows between two boundaries with asymmetric roughness the plane of maximum velocity is not the plane of zero shear stress. By dividing the flow at the plane of zero shear stress, laboratory and field data on flows below simulated and actual ice jams are analyzed to derive equations for the boundaries' friction factors in terms of mean flow velocity, depth of flow zone, and boundary roughness for smooth and fully rough boundaries. These equations are applied to the calculations of ice jam characteristics. For the jams studied, the present method gives a variation of about 10% in the jam characteristics with a method based on dividing the flow at the plant of maximum velocity. (Author's abstract)
W84-02872

COMPARISON OF OPEN CHANNEL CONSTRICTION RATINGS,
Colorado State Univ., Fort Collins. Dept. of Civil Engineering.
A. A. Fiuzat, and G. V. Skogerboe.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1589-1602, December, 1983. 1 Fig, 11 Tab, 9 Ref, 2 Append.

Descriptors: *Backwater, *Open-channel flow, *Submerged flow method, *Channel constrictions, Flow discharge, Bridges.

The problem of calculating the discharge through, or the backwater due to, open channel constrictions has been a research endeavor involving hyudraulic engineers for many decades. Most of the effort so far has been concentrated on laboratory data involving prismatic flumes, and less work has been done in collecting actual field data involving larger structures such as bridges. However, accurate discharge and backwater relationships are required based on laboratory data in order to expedite the calibration of larger field structures. The submerged flow method provides a promising approach for calculating the discharge or the backwater due to open channel constrictions. Two sets of data collected in two independent laboratory studies were utilized to compare the submerged flow method to other methods. The first set was used to calibrate the submerged flow equation, while the second set was utilized to verify the calibrations. The submerged flow equation was compared with other methods suggested for the same set of data by earlier investigators. The results showed very consistent discharge estimation by the submerged flow method. The submerged flow method is more versatile in application to design where the flow rate is know and the accompanying backwater due to a constriction is to be determined. (Moore-IVI)
W84-02874

SIDE DISCHARGES INTO OPEN CHANNELS: MATHEMATICAL MODEL,
Karlsruhe Univ. (Germany, F.R.). Sonderforschungsbereich 80.
A. O. Demuren, and W. Rodi.
Journal of Hydraulic Engineering, Vol. 109, No. 12, p 1707-1722, December, 1983. 12 Fig, 1 Tab, 22 Ref, 2 Append.

Descriptors: *Entrainment, *Side discharges, *Wastewater disposal, Effluents, Cooling water, Mathematical models, Open-channel flow, Turbulence, Jets.

Wastewater from sewerage treatment plants, or once-through-cooling thermal power plants, is often ejected through side discharges into rivers over the full depth. If the wastewater jet is discharged at moderate rates relative to the river discharge, it entrains ambient fluid on both the upstream and the lee side. The river flow is diverted by the jet towards the far bank, while the jet itself is deflected in the river flow direction. A three-dimensional numerical mathematical model for calculating the near field of side discharges into open channel flow is presented. The method employs the standard k-e turbulence model for determining the turbulent stresses. Two discretization schemes are considered, namely, the hybrid central/upwind differencing scheme and the quadratic, upstream-weighted differencing scheme. The latter produces improved numerical solutions for a number of recirculating flows. The predictions are compared with experimental observations of earlier investigators of isothermal side discharges into both rough- and smooth-bed open channel flows; each at discharge to cross flow velocity ratios of 0.3 and 4.0. The agreement is, in the main, satisfactory for all the different cases considered. Now that the 3D model has been found to perform well for isothermal discharges, and the need for employing a higher-order numerical scheme has been established, it can be extended for calculating heated discharges by introducing buoyancy terms into both the mean-flow and turbulence-model equations. (Moore-IVI)
W84-02880

Group 8B—Hydraulics

ANALYSIS OF RIVER MEANDERS,
San Diego State Univ., CA. Dept. of Civil Engineering.
H. H. Chang.
Journal of Hydraulic Engineering, Vol. 110, No. 1, p 37-50, January, 1984. 5 Fig, 1 Tab, 29 Ref, 2 Append.

Descriptors: *Meanders, *Sediment load, *Channel slope, Curvature, River flow, Energy gradient, Bed slope.

The meander curvature and other geometric features for rivers are analyzed using an energy approach together with relations for flow continuity, sediment load, resistance to flow, bank stability, and transverse circulation in channel bends. Geometric variables of meanders are obtained so that the inflow water discharge and sediment load for the watershed are transported with minimum power expenditure per unit channel length and equal power along the reach. Minimum power also means minimum channel slope or energy gradient for the given conditions. The water and sediment inflow, which are determined in the watershed, are such that the channel slope so produced is usually different from the valley slope. Meander develops so that a river with a flatter slope can exist on the valley slope. The analysis establishes the maximum curvature for which a river does the least work in turning. This curvature, stated as the radius of curvature to channel width ratio, has an average value of 3; it shows only minor variation within the meandering range. Meandering represents a degree of adjustment for rivers. A meander curvature increases the power expenditure due to secondary currents, but this is matched by a compensating increase in the sediment efficiency associated with the transverse bed slope. Thus, uniform utilization of power and sediment continuity are maintained throughout the river reach. (Moore-IVI)
W84-02881

8C. Hydraulic Machinery

HYDROELECTRIC GENERATORS WITH A REMOVABLE ROTOR CORE,
B. N. Vasil'ev, V. A. Linyuchev, and N. A. Filatov.
Hydrotechnical Construction, Vol. 17, No. 3, p 209-212, May, 1983. 1 Fig, 2 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 5, p 13-14, May, 1983.

Descriptors: *Electrical equipment, *Hydroelectric plants, Turbines, Design criteria, Kegum hydrostation, USSR, Daugave River.

In the USSR the first experience of using a removable rotor core (RRC) was gained while expanding the Kegum hydrostation on the Daugave River, where three 64-MW units with a 9.3 m-diameter Kaplan turbine were installed in a new powerhouse. The use of the RRC made it possible to dispense with one of the two originally planned 250-ton semigantry cranes. Preliminary calculations showed that the use of the RRC for such units is economically justified up to the installation of six units. These calculations took into account that the one-time saving due to reducing the capacity of the cranes is offset by an increase in the cost of assembling each unit with a RRC. For conditions of the Kegum hydrostation the total calculated saving was about 200,000 rubles. (Baker-IVI)
W84-02652

8D. Soil Mechanics

DETERMINATION OF THE ADDITIONAL EARTH PRESSURE ON THE CHAMBER WALLS OF TWIN LOCKS,
A. B. Moshkov.
Hydrotechnical Construction, Vol. 17, No. 4, p 181-190, April, 1983. 6 Fig, 11 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 4, p 42-47, April, 1983.

Descriptors: *Earth pressure, *Locks, Earth dams, Votkinsk Lock, Pressure, Soil properties, Construction, Standards.

During comprehensive on-site observations of the working of the Votkinsk lock in May and June of 1964, it was discovered that there was an effect of pressure from the lock chamber being filled transmitted through the soil in the interlock space to the adjacent lock. During filling of one of the twin lock chambers possessing a small width of interlock space, the relatively flexible wall of the chamber being filled, bent toward the backfill, compressing the soil filling this space to such a degree that it began to press the wall of the adjacent chamber. The instructions of SNiP II-55-79 for determining the additional earth pressure give overestimated values of this pressure, which do not agree with the data of on-site observations. The soil reaction pressure behind the outer walls of the chamber being filled from their bending by the water determined for the case of controlled backfill is underestimated. When calculating chambers of twin locks for hydrostatic loads it is recommended that the soil reaction pressure behind both walls of the chamber being filled be determined by means of calculation schemes used for single land locks. The additional earth pressure being transmitted through the backfill of the interlock space to the adjacent chamber should be determined in fractions of this reaction pressure by relations which are given. In calculations of the strength of lock chambers it is suggested that the shear stresses be taken into account on the contact of the soil with the backs of the walls. This will make it possible to reduce the calculated area of reinforcement. Furthermore, consideration of friction forces in calculations for the hydrostatic load will permit using lower levels of backfill behind the chamber walls, which will ease their work and permit designing more economical structures. (Baker-IVI)
W84-02651

EARTH REINFORCED DAMS: FIRST IN U.S.
Civil Engineering, Vol. 53, No. 10, p 60-63, October, 1983. 1 Fig.

Descriptors: *Dam construction, *Earth dams, Reinforced earth, Texas, Colorado, Montana, Austin, Design criteria, Costs.

Earth reinforcement for dam restoration and construction have brought an average dollar savings of as much as 30% compared to other design alternatives. A patented product, Reinforced Earth provides a means of improving the mechanical properties of basic material, earth, by reinforcing it with metal strips. The galvanized steel strips reinforce the earthfill in the directions in which it is subject to the greatest stresses. The backfill is essentially granular, composed of sand, gravel or crushed stone. A facing prevents erosion of the backfill and provides a finished surface. Design considerations are dictated by site requirements. In building the Woodhollow Dam, the City of Austin, Texas, faced space constraints and public pressure to build an attractive structure. The 344 ft long water storage and flood control dam was built between two large apartment complexes. The first reconstruction project in the United States using reinforced earth was for a deteriorating 110 yr old stone masonry dam in Jamesville, NY. Similar work has been investigated for the Lake Sherburne Dam in Montana, and the Taylor Draw Dam in Colorado. (Baker-IVI)
W84-02773

8E. Rock Mechanics and Geology

GEOTECHNICAL ASPECTS OF THE KIELDER DAM,
J. P. Millmore, and R. McNicol.
Proceedings of the Institution of Civil Engineers, Vol. 74, Part 1, p 805-836, November, 1983. 23 Fig, 11 Tab, 11 Ref.

Descriptors: *Dams, *Geology, *Embankments, *Kielder Dam, River North Tyne, England, Seepage, Reservoirs, Interstitial water, Dam design.

Kielder Dam on the River North Tyne (England) was constructed between 1976 and 1982 and forms Kielder Water, an impounding reservoir with 188,000,000 cu m usable storage. Since completion of construction and impounding, movements measured in the dam have been very small. Pore-water pressures in the embankment appear to be stabilizing, although long term steady-state seepage through the dam has yet to be established. Monitoring to date shows that the present underseepage is less than the various predictions and justifies the controlled underseepage design philosophy adopted for the dam. There can be no doubt that extensive materials testing ensured a dam of known characteristics which gave confidence in the design used; instrumentation monitoring of movement and pressure permitted stability assessments to be made on a continuous basis. Future recording of selected instruments will ensure an understanding of the behavior of the dam in service. Rapid construction of the embankment dictated close control of the fill materials and the monitoring of pressures and deformations, which revealed the need for two stability berms. (Baker-IVI)
W84-02507

CHARACTERISTICS OF THE MECHANICAL PROPERTIES OF ROCKS,
T. F. Lipovetskaya.
Hydrotechnical Construction, Vol. 17, No. 6, p 281-282, June, 1983. 1 Fig. Translated from Gidrotekhnickeskoe Stroitel'stvo, No. 6, p 6, June, 1983.

Descriptors: *Rock properties, *Dam construction, Earth dams, Rocks, Soil properties, Construction, Nurek dam, Strength.

When substantiating the designs of earth dams, especially when designing high and very high dams in seismic regions, the calculated values of the strength characteristics of the soils composing them have decisive importance. The methods of determining the calculated values of the characteristics of soil strength from the results of experimental investigations are standardized by construction specifications and regulations SNiP II-16-76. If the values of the strength characteristics obtained in conformity with the requirements of this standard were used in the calculations, dams could be designed of a sufficiently compressed profile. (Baker-IVI)
W84-02658

RELIABILITY OF ROCK FOUNDATIONS OF CONCRETE DAMS,
E. S. Kalustyan.
Hydrotechnical Construction, Vol. 17, No. 6, p 282-285, June, 1983. 1 Fig, 4 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 6, p 7-8, June, 1983.

Descriptors: *Dam failure, *Rock properties, *Foundation rocks, Dam construction, Design criteria, Filling, Foundation failure, Earthquakes, Floods, Seepage, Water pressure.

Many factors influence the reliability of rock foundations in dams including the action on the structure of water pressure during filling of the reservoir, floods greater than the design probability, earthquakes, typhoons, climatic factors, and the environment. The structure itself is also a factor, including the dam, and the foundation. Destruction of the foundation under the action of the external medium (EM), by which is meant the action of water pressure during filling always leads to failure of the entire system, and the failure of the dam involves the destruction of the foundation. The majority of failures and damages of dams on a rock foundation (64.8%) occurred during filling of the reservoir, which made it possible to detect defects of the dam or foundation. The second cause in relation to significance is flow over the dam as a result of the passage of floods below the design probability (27.8%). Earthquakes and climatic factors gave 5.6 and 1.6%, respectively. The significance of earthquakes, however, should not be underestimated in connection with construction in regions of tectonic activity. The greatest number of failures and incidents - 34% is related to seepage in the foundation. The hydrostatic pressure of water in 29% of the cases led to shearing, formation of cracks, and displacement of the dams along

the foundation. Cases related to aging of the drainage system and uplift amount to 29% of the cases. The reliability of the constructed structures can be estimated on the basis of the general method of analyzing failures based on the use of a multifactor model. (Baker-IVI)
W84-02659

TEMPERATURE REGIME AND STATE OF THERMAL STRESS OF THE KURPSAI DAM,
For primary bibliographic entry see Field 8A.
W84-02661

8F. Concrete

TEMPERATURE REGIME OF THE CONCRETE DAM ON THE KURPSAI HYDROELECTRIC STATION DURING THE CONSTRUCTION PERIOD,
A. I. Tsarev, M. S. Kazachenko, and A. B. Kocharyants.
Hydrotechnical Construction, Vol. 17, No. 6, p 285-288, June, 1983. 4 Fig, 3 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 6, p 8-10, June, 1983.

Descriptors: *Concrete Dams, *Temperature, *Kurpsai Hydroelectric Station, Concrete, Dam construction, Hydroelectric plants, Powerplants, USSR, Concrete technology.

The climatic conditions of constructing the Kurpsai dam caused stringent demands on the temperature regime of the concrete during its placement and hardening, which amounted to restricting exothermic heating to 26 degrees C in the rock contact zone and 30 degrees C in the other parts of the structure and limiting the temperature in the direction from the foundation to the crest to 9 to 13 degrees and the core-face temperature difference to 20 degrees. The temperature regime of the concrete was observed by means of embedded string- and semiconductor-type temperature transducers placed at 13 levels with a spacing heightwise from 2 to 9 m. The temperature regime of the dam was found to meet the design and technical requirements imposed on concreting operations. Two characteristic zones of the temperature state of the concrete are noted in the Kurpsai dam: a central zone where the temperature stays at the level of 23 to 24.5 degrees C and is slowly decreasing at a rate of 1 to 1.5 degrees/year; and an outside zone of the dam at a depth of 6-7 m where the temperature regime depends on seasonal variations of the air temperature. Surface watering is an effective means of reducing temperature of the concrete at an early stage of its hardening. (Baker-IVI)
W84-02660

EFFECT OF AUTOGENOUS HEALING OF CONCRETE SUBJECTED TO PERIODIC FREEZE-THAW CYCLES,
S. S. Sukhotskaya, V. P. Mazhorova, and Yu. N. Terekhin.
Hydrotechnical Construction, Vol. 17, No. 6, p 294-296, June, 1983. 3 Fig, 1 Tab, 5 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 6, p 14-15, June, 1983.

Descriptors: *Concrete, *Temperature effects, *Freeze-thaw cycle, Autogenous healing, Concrete dams, Dam construction, Elasticity, Concrete technology.

The effect of autogenous healing of concrete on its frost resistance was studied under laboratory conditions on mortar and concrete specimens. The change in the structure of the concrete was evaluated from the results of determining the compressive strength and on the basis of the dynamic modulus of elasticity. During tests with continuous freeze-thaw cycles the values of the indices of the main physical and mechanical properties of the concrete and mortar decreased more rapidly than during tests with breaks. As a result of the healing of the concrete, which is displayed more noticeably in the initial test period, the time of failure of the concrete is considerably postponed. Fracture processes during continuous testing develop with acceleration. A similar regularity is noted for each measured parameter, although with respect to absolute value and character of change a definite difference also exists between them due to the different sensitivity to disturbance of the structure. As a result of the break in testing the concrete specimen's modulus of elasticity (Ed), after 200 cycles, increased from 90 to 95%. After 400 cycles Ed of concrete during discontinuous testing decreased to 91% and after a month's break again reached 95%. At the same time the value of Ed of concrete during continuous testing decreased to 84% by 400 freeze-thaw cycles. By 600 cycles Ed during discontinuous testing was 90%, and Ed of concrete during continuous testing was equal to 80%. (Baker-IVI)
W84-02662

CONSIDERATION OF THE EFFECT OF CONSTRUCTION JOINTS ON THE STRENGTH OF MASSIVE REINFORCED-CONCRETE COMPONENTS,
A. P. Kirillov, V. B. Nikolaev, B. S. Belen'kii, O. D. Rubin, and V. M. Braude.
Hydrotechnical Construction, Vol. 17, No. 6, p 323-329, June, 1983. 2 Fig, 2 Tab, 14 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 6, p 33-36, June, 1983.

Descriptors: *Concretes, *Joints, *Reinforced concrete, Concrete dams, Dam construction, Dam design, Costs.

When designing massive reinforced concrete components and their elements it is necessary to consider the presence of construction joints between the blocks. The developed design requirements imposed on elements of massive reinforced-concrete components having construction joints and the method of calculating the strength of inclined sections permit a rational arrangement of the construction joints, ensuring reliability and durability of the structures. A differentiated approach to carrying out measures on the surface of blocks in conformity with the graph presented is offered. The cost effectiveness of using the proposed solutions is expressed in a reduction of the cost of works. The proposed solutions permit an experimental and theoretical evaluation of the state of operating reinforced-concrete components on the basis of the strength of inclined sections in the zone of construction joints, which in certain cases effects a savings due to elimination of costly investigations and repair works. It is expedient to introduce the given suggestions into the standards during their revision with respect to the calculation and design of massive reinforced concrete components and their construction. (Baker-IVI)
W84-02664

LINING TUNNELS: TOUGHEST CONCRETING JOB.
For primary bibliographic entry see Field 8B.
W84-02775

8G. Materials

POSSIBILITY OF FACING THE UPPER STORAGE RESERVOIRS OF PUMPED-STORAGE STATIONS WITH POLYMER FILM MATERIALS,
V. D. Glebov, and V. P. Lysenko.
Hydrotechnical Construction, Vol. 17, No. 5, p 247-250, May, 1983. 2 Fig, 4 Ref. Translated from Gidrotekhnicheskoe Stroitel'stvo, No. 5, p 32-34, May, 1983.

Descriptors: *Reservoirs, *Films, *Polymers, Pumped storage, Construction, Dams, Russia, Design criteria, Soil properties.

Watertight film materials can be used for facing the upper reservoirs of pumped storage stations. Use of such material is expedient not only on the slopes of the dike, but also over the entire area of the reservoir. The main conditions for the successful introduction of film facings on the upper reservoirs are the provision of stability of the faced slopes of the dikes and the development of technological schemes of construction works minimizing the danger of damaging the film. Watertight film structures made in the manner of inclined membranes can be recommended for dikes, and the technological schemes of placing the watertight film elements both on the slopes of the dikes and over the entire area should be planned without travel of the construction mechanisms on the protective layer, by using mechanisms of the elevating-grader type. (Baker-IVI)
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